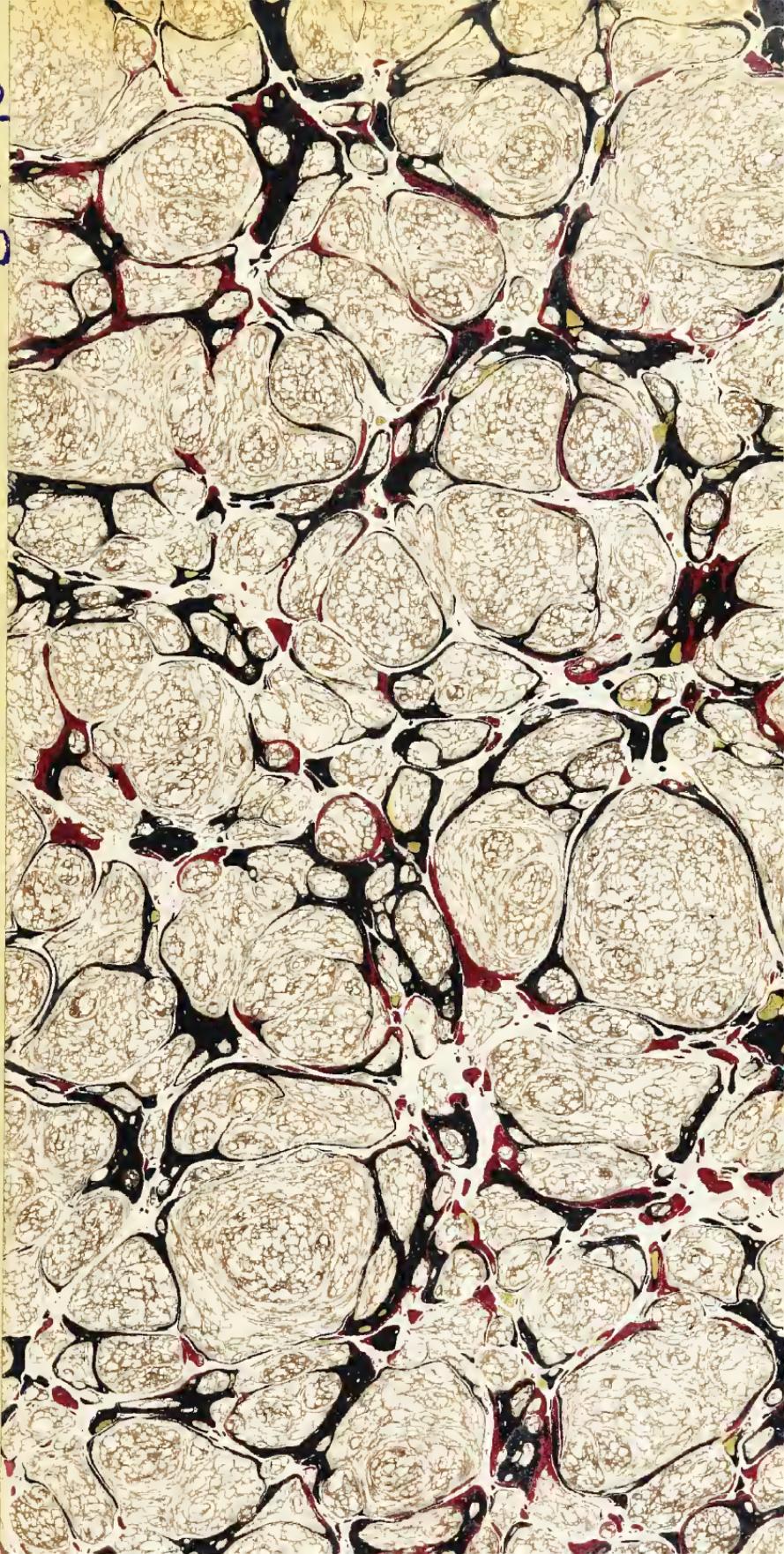


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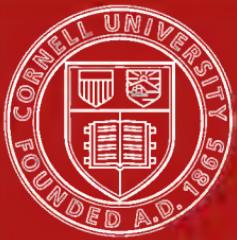
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PREFACE.

THE district described in the present Memoir embraces that portion of the County of Northumberland, which extends along the coast from Newton Point to beyond Haggerstone Castle, and inland as far as a due north and south line passing through Wooler. It covers a land-area of about 150 square miles, and includes the group of the Farne Islands and Holy Island.

The map of this district was surveyed by Mr. William Gunn, under the supervision of Mr. H. H. Howell, at the time when Mr. H. W. Bristow was Director of the Geological Survey of England and Wales. Mr. Gunn has likewise prepared the following account of the geology of the ground. It will be observed that the older sedimentary rocks of the district belong entirely to the lower portion of the Carboniferous system, and contain a fairly complete representation of the Carboniferous Limestone as this division is developed in the north of England. Each of its three groups is well displayed—the upper limestones, the middle coals, and the lower sandstones and cement-stones. There is a further feature of interest presented by the most northerly extension of the great Whin Sill, which can be conveniently examined in many excellent coast-sections.

In the Appendix a number of Lists of Fossils will be found. The first of these gives the localities from which fossils have been obtained by the Geological Survey, chiefly by the Fossil-Collector, Mr. John Rhodes; it also gives the specific names of the fossils as these have been determined by the palæontologists, Mr. George Sharman and Mr. E. T. Newton. The other lists show the palæontological results obtained from the district by previous observers.

ARCH. GEIKIE,
Director-General.

Geological Survey Office,
28, Jermyn Street, London,
25th November, 1899.

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THE GEOLOGY OF BELFORD, HOLY ISLAND, AND THE FARNE ISLANDS, NORTHUMBERLAND.

CHAPTER I.—INTRODUCTION.

PHYSICAL FEATURES.

THE Map to be described in the present Memoir embraces an area of about 150 square miles, and the whole of it now forms part of the county of Northumberland, though up till the year 1844 the northern portion, together with the Island of Lindisfarne or Holy Island, were included in North Durham, which extended northwards to the River Tweed. The little stream which runs by Detchant park, between Detchant and Buckton, is still known as the County Burn.

The greater part of the mainland is drained by several small streams which run directly into the North Sea on the east side. Of these may be mentioned Berrington Burn, the Low, near Lowick, Elwick Burn (one of whose branches is the County Burn), Waren Burn, which runs by Warenford, and Long Nanny, which rises in the district to the south of this. The smaller portion in the south-west is drained by the River Till (an affluent of the Tweed), and its branches, Wooler Water and Hetton Burn.

The watershed between these two areas is for the most part formed by a sandstone ridge—nearly everywhere over 500 ft. above the sea—which runs from south to north somewhat west of the central part of the map. South of Lowick, however, the watershed turns to the north-west over ground comparatively low and tame (from 300 to 400 ft.), and it leaves the district at Bar-moor.

The highest point is Ross Castle, 1,036 ft., at the south edge of the Map, south-east of Chillingham. To the north-east of this is Willie Law, 815 ft.; Kay Hill, Amersidelaw Moor, is 720 ft. Following the line of watershed northward we come to Chatton Park Hill, 603 ft.; Lyham Hill, 637 ft.; Dancing Green Hill, near Old Hazelrigg, 662 ft.; Cockenheugh, 692 ft.; Greensheen Hill, 664 ft.; Shepherd's Kirk Hill, 661 ft. (the highest point is not marked in the one-inch Map). The Kyloe Hills attain a height of about 520 ft., but this is not the highest point the Whin Sill reaches, for Fawcet Hill, north of Detchant Coal Houses, is 551 ft. Other conspicuous hills formed of whin are the Chapel Hill, Belford, 354 ft., and Spindleston Heugh, 244 ft. To the south of Belford there are not many conspicuous hills, but the following may be noticed—the Law Plantation, east of Warenton, 578 ft.; Longstone Hill, Lucker Moor, 657 ft.; and Isabella's Mount, south of Warenford, 462 ft.; these are formed of sand-

stone. There is a high range at the western edge of the Map running northward parallel to the watershed ; it is broken through by the river Till between Wooler and Doddington. The highest points along this range are Weetwood Moor, 547 ft. and 543 ft. ; Dod Law, near Doddington, 654 ft. ; and Doddington North Moor, 552 ft. The alluvial flat south of Doddington, which is a part of Millfield Plain, is not much more than 100 ft. above the sea.

From the central moorland there is a general slope eastward to the arable ground bordering the railway, and ranging mostly between 50 and 300 ft. This part is undulating and drift-covered with numerous peat bogs, which were once lakes. There is still the remains of one of these called Newham Lough, in Embleton's Bog, between Lucken and Newham. North of Budle Bay there is a considerable extent of blown sand forming Ross Links, the highest point of which is 65 ft., and sand hills attain a height of 87 ft. near Greenhill, east of Bamburgh. Near Holy Island there is a large tract of foreshore laid dry at low water ; of this the part opposite Beal is sand, and the Fenham Flats are mostly mud.

Of the islands off the coast, the largest, Holy Island, or Lindisfarne, is low, and much of it covered with sand and drift. The Castle only rises to 100 ft., and no other part of the island is above 69 ft. The Farne Islands are all rocky and none of them high. The Farne rises to 61 ft. and Staples Island to 46 ft.

The principal places are Belford, Wooler, Lowick, Holy Island, Bamburgh, North Sunderland, Beadnell, Ellingham, Chillingham and Chatton.

TABLE OF FORMATIONS.

Post-Glacial and Recent.	{ Blown Sand. Marine Alluvium, Raised Beaches. Freshwater Alluvium.								
Glacial.	Sand and Gravel, Boulder Clay, etc.								
Carboniferous Limestone Series. (d ³ and d ²).	<table> <tbody> <tr> <td>4. Limestone Group or Calcareous Division, down to base of the Dun Limestone. Thickness about -</td> <td>1,500 ft.</td> </tr> <tr> <td>3. Scremerston Coal Group or Carbonaceous Division. Thickness -</td> <td>600 „</td> </tr> <tr> <td>2. Fell Sandstone Group or Arenaceous Division. Thickness -</td> <td>700 „</td> </tr> <tr> <td>1. Cement Stone Group or Tuedian Division Thickness -</td> <td>600 „</td> </tr> </tbody> </table>	4. Limestone Group or Calcareous Division, down to base of the Dun Limestone. Thickness about -	1,500 ft.	3. Scremerston Coal Group or Carbonaceous Division. Thickness -	600 „	2. Fell Sandstone Group or Arenaceous Division. Thickness -	700 „	1. Cement Stone Group or Tuedian Division Thickness -	600 „
4. Limestone Group or Calcareous Division, down to base of the Dun Limestone. Thickness about -	1,500 ft.								
3. Scremerston Coal Group or Carbonaceous Division. Thickness -	600 „								
2. Fell Sandstone Group or Arenaceous Division. Thickness -	700 „								
1. Cement Stone Group or Tuedian Division Thickness -	600 „								
Igneous (B.)	Intrusive sheets and dykes of Basalt or Dolerite.								

4. *Limestone or Calcareous Division.*—Sandstone and shales, with many thin coals, some workable. Distinguishing characteristic, many thick marine limestones. Many fossils in the limestones. Thickness 1,500 feet.

3. *Scremerston Coal or Carbonaceous Division.*—Sandstones and grey or dark shales with comparatively thick coals, and a few thin whitish compact limestones with plant-remains. Fossils :—

Plants and shells in limestones, fish-remains. Thickness 500 to 700 feet.

2. *Fell Sandstone or Arenaceous Division*.—Almost entirely sandstones; whitish brown and red, thick-bedded and mostly rather coarse. No coals, or but very thin ones near the top. *Archaeodon Jukesi* is the only fossil except traces of plants. Thickness 600 to 800 feet.

1. *Cement Stone or Tuedian Division*.—Shales, grey, green, and chocolate-coloured, with thin bands of limestone and cement stones. Thick beds of white and red sandstones. No coals and no fossils found in this district, except some plant-impressions.

GENERAL GEOLOGICAL DESCRIPTION.

Lie of the Beds and Connection between the Form of the Ground and the Geological Structure.

The Tuedian—the lowest division, but poorly seen—is found in the south-west corner of the map, west of the Wooler Water, and it probably underlies the alluvial flat north of Wooler. The dip is gently eastward, mainly like that of the overlying mass of the Fell Sandstone group which forms Weetwood Moor, Dod Law, and the moors to the northward. Eastward of the Fell Sandstones comes a tract occupied by the beds of the Scremerston Coal Series and some of the Calcareous Group above. These lie in a much broken synclinal, the eastern edge of which ranges from The Low, opposite Lowick, southwards by Hetton Hall, and obscurely down Hetton Burn and along the Till Valley to Chillingham Castle. To the east of this and along a parallel line come the Tuedian Beds, brought up again between Chillingham Park and Holburn, in the centre of a marked anticline which ranges northward to Kentstone. This tract of Tuedian is bounded by a steeply-dipping or vertical band of Fell Sandstones on the west, and on the east by the same beds which have a somewhat gentle easterly dip, and occupy the central moorland from Ross Castle to Shepherd's Kirk. Several large faults ranging north-easterly, and mostly throwing down to the south, cross these beds, and also the overlying Scremerston Coal Series, which occupies a rather narrow band to the eastward. The ground bordering the railway and between it and the sea is occupied by the Limestone Group or Calcareous Series. North of Belford these beds generally dip seaward, but south of Belford they undulate a good deal in obscure ground, much broken by faults in the eastern part. Along the coast from Budle Bay southwards the strike is generally nearly east and west, or at right angles to that of the south-west part of the map, and there is an anticlinal line ranging through North Sunderland. In no part of the area is the dip high except along the west side of the Chillingham-Holburn anticline, where it is vertical in many places. In general the average dip is about 10°.

The Tuedian beds make no prominent features; most of these are formed by the Fell Sandstones in the two tracts of high ground formerly described, where the steep scarps are on the west side and the gentle slopes on the east side, mainly with the dip. Sometimes the sandstones in the Carbonaceous and Calcareous Groups form prominent features, as at Doddington North Moor, and near Wrangham, Warenton, &c.

The limestones, though some are from 20 to 30 ft. in thickness, scarcely ever form crags or scars, except in banks of streams, and rarely stand out clearly at the surface; in fact they are almost universally either drift-covered or their outcrops are level with the general surface and scarcely noticeable, and there are no swallow holes by which the beds can be traced, as they can in some districts, so that over large areas the limestones cannot be mapped. It is possible that in some places where the rock has been quarried there may have been formerly small scars or crags like that now seen at Bellshill Quarry. The basaltic sheets of the Whin Sill form a pretty continuous belt of craggy ground from the Kyloe Hills to Belford, and eastward to Bamburgh and the Farne Islands, the crag being almost always on the rise or outercrop side, *i.e.*, on the west or south. Some of the more prominent features in the low ground about Lucker and Newham are formed by drift.

Historical Sketch of G. Tate's Classification of the Carboniferous Beds of Northumberland.

In his address to the Berwickshire Naturalists' Field Club in 1853 (meeting at Cockburnspath), Mr. G. Tate, after describing the beds about the Pees Mouth and Cove Harbour, and saying "They synchronize with the lower Carboniferous beds which appear on the Whiteadder and on the Tweed," goes on to describe them, and then adds:—"The rocks which I have attempted to describe form a distinct division in the Carboniferous formation, lying far below the Productal and Encrinial limestones of Northumberland and East Lothian, and are well marked by the abundance of fish remains, by the comparatively small amount of carbon, and by the slight indication of marine conditions."*

In the year 1856, Mr. Tate proposed the term *Tuedian* for these beds. After describing beds about Coldstream, and observing that they "form part of an interesting series which is well seen from Carham to Norham," &c., he goes on to say "These beds form the lowest portion of the Carboniferous formation, lying below the Productal and Encrinial Mountain Limestone of Northumberland, and might properly be designated as the *Tuedian Group*. They are distinguished by the peculiarity of the shales, by the thin beds of magnesian limestone, by the absence of Brachiopods and by the presence of *Modiolu*, Entomoscobra and Fish-remains.†

* *Proc. Berwick Nat. F. Club.* Vol. iii., pp. 134-5.

† *Proc. Berwick Nat. F. Club.* Vol. iii., pp. 218, 219.

In 1859 Mr. Tate divided the Carboniferous formation of Northumberland into four groups, viz.:—1. The Coal Measures; 2. The Millstone Grit; 3. The Mountain Limestone; 4. The Tuedian Group. He gives short descriptions of each of these groups, but does not define their exact limits.*

In 1866† he divided the Mountain Limestone (with a total thickness of 2,600 feet) into two divisions:—

The *Upper* division, including the beds from the base of the Millstone Grit to the base of the Dun Limestone, 1,700 ft.

The *Lower* division, including the beds from the base of the Dun Limestone to the top of the Tuedian Group, and having a thickness of about 900 ft.

For the *Upper* division, distinguished by the number and thickness of its limestones, he proposes the term *Calcareous*.

For the *Lower* division, especially marked by the number, thickness and quality of its coal-seams, he proposes the term *Carbonaceous*.

This triple division of the Carboniferous rocks below the Millstone grit, viz., Calcareous Group, Carbonaceous Group, Tuedian Group—Tate adheres to in subsequent descriptions of Northumberland rocks.‡

* *Proc. Berwick Nat. F. Club.* Vol. iv., pp. 150, 151.

† *Ibid.* Vol. v., p. 283.

‡ *Nat. Hist. Trans. of Northumberland and Durham.* Vol. ii., p. 6 (1868); *History of Alnwick.* Vol. ii., p. 444 (1868-69). For further references to the term "Tuedian," see *Proc. Ber. Nat. F. Club.* Vol. iv., p. 122; and pp. 223-249. Vol. v., p. 187; and Vol. v., p. 365.

CHAPTER II.—CARBONIFEROUS.

CEMENT STONE GROUP, OR TUEDIAN DIVISION.

As only a few hundred feet of these beds are found in this area, and they are somewhat imperfectly seen, the reader is referred for a fuller account of this group to the memoir on the adjoining quarter-sheet, 110 S.W., where will be found a description of it as seen in the typical district along the banks of the Tweed.

The outcrop of the Tuedian in the south-west corner of the area, west of Wooler Water, is nearly everywhere concealed under a great thickness of drift gravel and sand; but in one place about a mile south of Wooler, sandstones of this group seem to occur at or near the surface, many angular pieces, apparently of these beds, being ploughed up in the fields. They occur just at the extreme edge of the map, opposite Haughhead.

On the east side of Wooler Water, too, very little is to be seen of these beds: but probably they outcrop under clay at the bottom of the sandstone bank east of Wooler Brewery and also further north towards West Weetwood. To the southward the base of the overlying Fell Sandstones appears to quickly come close down to the alluvium, and as the Old Red Porphyrites of the Cheviots crop out just west of the edge of the map, there is only left for the Tuedians here a width of outcrop not much over half a mile. It is not likely that this obscure tract is occupied by highly-dipping beds, and the explanation probably is that the beds are comparatively thin here and overlap the Porphyrites, and perhaps also are faulted against them. The northern boundary of the Porphyrites from Wooler westward is probably a fault, as described in the Explanation to Sheet 110 S.W., and it is likely enough that this fault is prolonged up the valley of the Wooler Water, throwing down higher beds on the east. But there is no evidence that the fault is a large one, not by any means large enough to account for such an apparent diminution of the beds, from about 3,000 ft. along the Tweed to some 300 or 400 ft., which is all we can allow here, judging by the dip of the overlying sandstone of Weetwood Moor. Beds of this group probably underlie the low sandy tract south of Doddington between the road and the alluvium of the River Till.

These beds come up again in the Chillingham-Holburn anticinal, but there are few good sections, and we nowhere see the lowest beds, and probably only about 600 or 700 ft. at the most. They must occupy a large part of the area of Chillingham Park, but the streams run for the most part in drift, and little is seen of the solid rock. There is, however, a section in a small stream at the south-east corner of the park—but just outside our area—showing shales, thin sandstones and cement stones (or impure limestone), dipping eastward at 9° under the mass of the Fell

Sandstones forming Ross Castle. Under Chatton Park hill to the north-east of Chatton, pieces of green shale and clay and thin yellow sandstone are ploughed up at the top of some of the fields there, just west of the highest part of the hill. To the north of this the Allery or South Lyham Burn to the S.W. of South Lyham, gives some rather poor sections in greenish-grey and soft yellowish sandstones, some being thin, micaceous, and shaly, with shales and cement stones. The dip is mostly to the E.N.E. at about 10° , but the beds appear to undulate in places.

Northward from this burn the ground is obscured by drift and we see nothing of these beds till we come to a little stream between South Hazelrigg and Old Hazelrigg, in which there is a small section in shale and sandstone dipping N.E. at 12° , below the Fell Sandstone. Immediately west of North Hazelrigg there is another small section in greenish shale, thin grey sandstone and cement stone, with shales and sandstones below, dipping N.E. about 10° . North of this we arrive at the Hetton and the Horsedean Burns, which give fuller sections. The best is that shown in the Horsedean Burn and its continuation south of Holburn Grange. This stream runs nearly along the township boundary between North Hazelrigg and Holburn Grange and is not shown on the one-inch Map. There are also sections in Hetton Burn both above and below its junction with the Horsedean Burn. The west side of the anticlinal is very steep, so that here in the Hetton Burn and in the lower part of the Horsedean Burn we find the beds dipping to the west at angles as high as from 50° to 70° . They consist of whitish and grey sandstones, purple and grey shaly sandstone, thick grey shales, and alternations of sandstones, shales and cement stones with thin impure limestone. In the Hetton Burn a little below the base of the Fell Sandstones is the following section :—

Sandstone, rather thin bedded	...	...
Shales and cements	...	...	...	12—15 feet,
Sandstone, at least	...	...	...	20 "
Cements	...	...	...	2—3 "
Shales and cements	...	...	...

The cement stones are compact impure limestones of a yellowish or cream colour; they are generally very thin, a few inches at most, and frequently alternate with shales. Where the Horsedean Burn (which in the lower part of its course trends to the north) takes a bend to the eastward, we find the dip changes, first to northwards at 10° and then to N.E. and to E.N.E. at angles of from 15° to 60° , but generally low, so that we pass over the axis of the anticlinal. There are beds of shale containing thin bands of hard grey sandstone, looking much like limestone. The section ends with the plantation, where the boundary and also main burn trend southwards, but we get small isolated sections in shales and sandstones dipping easterly at angles between 10° and 50° in the two northern branches of the burn. The best section, however, is in the branch not marked on the map, which follows the township boundary and runs through a plantation to the eastward. Towards the west side of the plantation the

stream runs mainly through shales and cements with in one place a thin limestone, and thin bands of sandstone. The eastward dip varies from 7° to 20° , undulating a little in places. About the middle of the plantation comes a considerable thickness of sandstone, yellowish white and felspathic, which has been quarried close to where the footpath from Holburn Grange crosses the burn. Above this come shales and cements again, and then more sandstone, this time rather coarse, red and yellow; then occurs a gap in the section till, just beyond the southern bend in the plantation, we find thin-bedded hard fine grey sandstone with plant-remains, and then one or two small sections in shale.

Nearly half a mile E.S.E. of Holburn a stream gives small sections in the beds just below the Fell sandstones; the dip is E.N.E. at 12° to 15° . The highest beds seen are grey and reddish shales with cements: lower down appears grey clay, and still lower comes thin sandstone. Little is seen of the steep western side of the anticline to the south of Hazelrigg Mill. There is a solitary section in the N. bank of the Till near West Lyham showing about 20 feet of grey, greenish and reddish shale with thin bands of yellow sandstone dipping westward 80° to 90° , and sandstone is said to have once been quarried close by. There is a doubtful trace of coal, and this may be about the upper boundary-line of the group.

The anticlinal band we have been describing is narrow in places, as at South Hazelrigg and near Chillingham; in fact its breadth of outcrop is often changed by the large faults which cross it and which can be clearly traced along its eastern margin, but how far these faults extend in the drift-covered area to the westward is uncertain.

As no fossils were collected from the Tuedian group in this area, it has been thought advisable to give a list of those collected in the adjoining sheet to the west, 110 S.W.

LOWER CARBONIFEROUS OR TUEDIAN FOSSILS.

PLANT.E.

Araucarioxylon Withami.

Samaropsis (Cardiocarpon) nervosa.

Triphylopteris convoluta.

ANNELIDA.

Spirorbis helicteres (also in Carbonaceous Division).

CRUSTACEA.

Ostracoda.

Leperditia.

BRACHIOPODA.

Rhynchonella pleurodon (ranges to Dryburn Limestone).

MOLLUSCA.

Lamellibranchiata.

Modiola Macadami (also in Carbonaceous Division).

subparallelia.

" *Myalina lamellosa* (?)

Sanguinolites.

Murchisonia elongata.
Natica.
Naticopsis.
Turbo.

Orthoceras.

Gasteropoda.

Cephalopoda.

PISCES.

Archichthys.
Ctenodus.
Ctenoptychius (Harpacodus) clavatus.
Gyracanthus.
" obliquus.
Rhizodopsis.
Rhizodus Portlockii (?)
Palæoniscoid scale (? Cosmoptychius).
Pristicladodus Goughii.
Psammodus.
Strepsodus.

CHAPTER III.—CARBONIFEROUS—(*continued*).

FELL-SANDSTONE GROUP OR ARENACEOUS DIVISION.

This great mass of sandstones does not seem to have been definitely recognised by Tate as a separate group, but was generally included by him in his Tuedian Series. In fact, sandstones of much the same character occur at various horizons in that series, though of course not nearly so thick as those we have classed separately and mapped as *Fell Sandstones*. The sandstones composing the group vary a good deal in colour and texture. There are some beds red or reddish, but more often the colours are brown, white, or yellowish. Some beds are coarse and pebbly, while others are very fine, but in general moderately coarse varieties prevail. In places, the sandstone is decomposed at the surface to a sand.

Owing to the thick and massive character of the rock and its having laminae of false-bedding, it is often difficult to make out the amount of true dip, especially where it is at low angles.

It is by no means certain that the lines we have drawn for the boundaries of this mass of sandstone are everywhere exactly the same; the upper boundary, being that of the lowest workable coal-seam, is very uncertain in places, as on Sandyford and Lyham Moors, where the coals have not been worked. The base of the group, too, is often obscured by drift, which covers the whole group for long distances in the “edge beds,” as we may term them, which run in a nearly straight line from Black Heddon to Chillingham.

As before mentioned, the Fell Sandstones form the ridge of high moorland stretching northwards from Ross Castle to Shepherd's Kirk Hill, and in all this part of their range the dip is easterly or north-easterly at comparatively low angles. Many large faults which will be noticed further on shift the outcrop. At Shepherd's Kirk the beds turn sharply round and dip at high angles of from 30° to 60° to westward, striking southward by Holburn, Holburn Mill, and down Hetton Burn, crossing eventually on to the west side of it, then past Hetton Hall, where they cross to the east side of the burn, and thence along the ridge west of Spylaw and West Lyham, losing themselves in drift and alluvium. They come out again at Amersidelaw and run along the west side of Chillingham Park in a narrow band. West of the Till they rise again with a gentle easterly dip, forming the moors between the Till and the Wooler Water as well as those north of the Till from Weetwood Hill by Dod Law northward to Doddington North Moor.

Detailed Description.

In the drift-covered country west of the Till no coals have been worked, and the upper limit of the Fell Sandstones is not clear. Roughly speaking, however, the road which runs southward from

near Weetwood Hall past Fowberry Mains is the boundary of the thick drift, and all is certainly Fell Sandstone to the west of this. Sandstone is only seen east of the road in one or two places south west of Bleaklaw. The sandstone has been largely quarried south of Newtown Moor on the east side of the road leading north-westward by Coldmartin Loch. The dip is south-easterly, probably about 10° , but the rock is mostly so thick-bedded that the dip is not easy to make out. The rock visible varies in texture from rather fine to rather coarse sandstone, the colour being whitish-brown and speckled, but there is said to be finer sandstone below. There are marked joints ranging W. 10° S. and dipping 75° - 80° northward. It was in this quarry at the bend in the road that *Archonodon Jukesi* was found in 1877.* Mr. Howse also found remains of *Ulodendron ornatum-tissimum*, branches of a Lepidodendroid plant, and stems of a Calamite. The quarry is in the parish of Chillingham Newtown.

About half a mile to the westward in a hollow on the eastern side of a large plantation an unsuccessful boring for coal was made to a depth of 240 feet, according to report.

There is a quarry at the north end of High Cairn Plantation in reddish-brown sandstone with some irregular bands a few inches thick of purple shaly breccia.

Over a large part of the area under description the dip seems small, but is generally eastward. There is a good feature west of Trickley, and the sandstone probably dips eastward, but the beds seem nearly flat at the quarry to the northward, in Trickley Wood. East of the wood also there is a quarry near the north end in fine thin-bedded sandstone which is nearly flat. Outside the north wall is another quarry in massive false-bedded sandstone, reddish-brown and whitish.

There is good deal of drift along the southern edge of this sandstone area—the edge of the map—but the rock crops out at the border of the alluvial flat of the Wooler Water about Haugh Head. Between the two places of that name is a hill of yellowish sandstone, and south of Haugh Head soft false-bedded red and mottled sandstone is seen in one place to the thickness of 20 ft. The rock also crops out in many places about Coldmartin, and over the ground to the northward sandstone occurs almost everywhere at the surface, in many places glacially smoothed and striated, and in others artificially sculptured with cups and circles of very old date. There are large old quarries near the crest of the hill west of Coldmartin Loch and just south of the road, showing:—

	Ft.
Coarse reddish sandstone, rubbly and irregular	10-12
Shaly sandstone parting	0-2
Fine false-bedded sandstone, several feet.	

About a quarter of a-mile north of this section there is fine flaggy stone in which the false-bedding dips westward, and a little to the north-east of this the sandstone is coarse, red and

* See papers by R. Howse and G. A. Lebour mentioned in the Bibliography.

brown, and very irregularly weathered, having veins of comparatively modern gravel in the joints, one of which goes down 6 ft. below the surface.

The cutting north of Coldmartin Loch is 10-12 ft. deep in massive false-bedded pinkish sandstone. To the north-east of this there is a rather deep quarry in a small plantation south-east of the Weetwood Bridge over the Till, showing:—

	Ft.
Sandstone, mostly broken and rubbly	15-20
Soft purplish coarse shale or breccia	2-3
Yellowish massive sandstone	20

North of the Till there is a small quarry close to the Ordnance Station, Weetwood Hill, in massive pinkish sandstone. Westward from this quarry there is in the fields much sand, some of which seems derived from decomposed rock. In the hill above rise thick beds of sandstone dipping north-east in several banks or scarps, till the highest is reached running under Dod Law, all composed of massive false-bedded whitish and pinkish sandstone. The dip now becomes more easterly and rock may be seen nearly all over the moor. There is a good feature of sandstone running from Dod Law Camp northward for nearly a mile to the Redsteads road. At Cuddie's Well, Doddington, the rock is coarse and reddish. North of Doddington and west of the main road there is a quarry in thick-bedded whitish and pinkish stone dipping easterly at about 10° , and reddish massive irregular stone, some coarse and felspathic, is visible in a quarry to the eastward by the side of the road to Redsteads. There are many exposures east of the road from Doddington to Berwick about the sculptured rocks; and sometimes the rock is pebbly and reddish. Further north, opposite Wrangham, and west of the main road, the rock is in many places soft and coarse, and there is a good section in a quarry where the dip is east at 15° .

The section is variable. In the middle of the quarry are:—

	Ft.
Fine rubbly sandstone	10-12
Coarse stone, quartzose and felspathic, with pebbles, about	15
Purple and yellow shale with quartz pebbles, looking like a breccia	0-1 or more.
Finer sandstone, seen for five feet.	

Further to the northward the beds turn round and dip nearly due north, so that several features are shown striking nearly east and west, which seem to be formed by alternations of whitish hard stone with soft rock, and near the house in Doddington North Moor the upper boundary of the Fell sandstones passes into the area to the westward.

To the south west of Chillingham Castle these rocks form a narrow band dipping westward at 45° . The outcrop is shifted eastward by a large fault, and the rock appears in the steep bank behind Chillingham Church and in Church Wood, coarse in places, yellow and brown, dipping south of west at angles of 40° to 60° . North of the wood another fault shifts it eastward, and it is exposed in a quarry south of Amersidelaw, soft red and

pink sandstone dipping south of west at 35° to 40° . North of this there is much drift and no trace of rock is seen till after passing the Till. The band seems to pass west of West Lyham and Spylaw, but may be crossed by several of the large faults seen on the moors to the eastward. Near South Hazelrigg the dip seems to be eastward at 35° to 50° in massive whitish stone, but there is some doubt if this is not jointing, and that the true dip is westward at 45° to 50° .

There is a fairly continuous ridge of sandstone northward to Hazelrigg Mill, where the dip is clearly W.S.W. and S.W. at angles of 40° to 90° . The sandstones then cross to the west side of the burn, but do not make much show till we arrive opposite the foot of Horse Dean Burn. There is a fine section of them in the Hetton Burn up to Holburn Mill; they are thick-bedded, reddish in places, and everywhere dipping steeply westward at 50° , 60° , 70° , or even 80° . The thickness here seems about 800 ft. The same steep dip continues past Holburn to the large fault at that place. In the stream west of the road just where the footpath crosses, the rock is red and coarse, with pebbles reaching one inch in length. This band of rock turns round to the eastward under Holburn with a more gentle northerly dip, but the same steep westerly dip continues to the north of the large fault. Soft, very coarse pebbly stone and soft conglomerate are seen east of the road, though at first the dip is not noticeable. Further north coarse sandstone dips west at 50° to 90° , and this is seen to curve sharply round to the eastward and dip more gently northward under Black Heddon Hill, the sandstone of which dips under Shepherd's Kirk Hill. The thickness about here seems quite as much as 750 ft. and may be nearly 1,000 ft. The upper limit is not easy to define, as the coals above have not been worked to the north and east. On Black Heddon the bedding is in places irregular and there is curved false-bedding, but the true northward dip is shown by the east and west features with dip slopes to the north. At Shepherd's Kirk, south of the Ordnance Station (604 ft.) marked on the map (but which is not the highest part of the hill), there is a crag and an interesting section, where the dip is north at 15° . It shows massive coarse pebbly grit, resting irregularly on fine sandstone.

The line of junction is honeycombed and shows the dip clearly. One block has a honeycombed surface below, with holes two to four inches wide and one to two inches deep. It is possible that the Dues Heugh sandstone belongs to the Coal Series. There is a pretty continuous feature here from the west side of Kyloe Plantation past Dues Heugh to near Lowick Forest House. All these beds are cut off on the east by the great fault which goes through Kyloe Plantation, and it seems there is a small patch of Tuedian west of the fault in the hollow south of Black Heddon.

From Holburn to the south end of Cockenheugh there is an unbroken stretch of the Fell sandstones bending round from the steep westerly dip to that of E.N.E. at 12° - 15° . To the north-east of Holburn they form several distinct features, probably from alternations of hard and soft stone, for there is no shale visible.

The sandstones are variable in character, some coarse and red, and thick-bedded, others flaggy, and some false-bedded. The upper boundary is covered by Holburn Moss, but further south it is fixed by the old coal-workings on the west side of it. The thickness about here must be 700 feet or more. There is a good section in Cuddie's (or St. Cuthbert's) Cave, which is 40 yards long and 8 yards broad, with a sloping roof which shows the dip clearly. South of the Ordnance Station, 692 ft., are many caves and stacks in massive reddish sandstone with irregular conglomerate bands. Some of these caves, &c., seem to have had a marine origin. Eastward from these, on the other side of the hill, there is a quarry in laminated sandstone dipping E.N.E. at 20° . The large Cockenheugh fault having a throw down south of 700 to 800 ft. shifts the outcrop more than half a mile to the westward, so that the base of the sandstones is at Old Hazelrigg, where the dip—N.E. to E.N.E.—is 10° to 12° , increasing eastward to 20° or more at Girney Nick, where the Cooper Eye Coal has been worked. South of Dancing Green Hill, 662 ft., another fault throwing down south, though not so large as the preceding, shifts the outcrop westward again. The throw is perhaps 200 ft. The base is now obscured by drift, but the Cooper Eye seam above has been worked along to the next fault, which is a very large downthrow south, and shifts the outcrop of the beds far to the west. South of this fault the coals above have not been worked and the exact position of both base and top is uncertain, seeing that no shale is visible, and that there are thick sandstones which form marked features in the coal series, added to which a good deal of drift comes on the southward. It would seem, however, that the coarse sandstone of Lyham Hill must be part of the Fell sandstone, and the rock in places coarse and yellow, appears to beat the surface, all down the road to Old Lyham, where the dip is at 20° to the E.N.E. Another large fault, throwing down south, probably 600 ft. or more, north of Chatton Park Hill shifts the outcrop again far to the west. The rock is seen nearly all over this hill, which has a steep scarp to the west, and the thickness is about 800 ft. The stone is sometimes coarse, and is generally too massive to show the dip well. There is a quarry near the base to the north of Parkhouses, in massive whitish and yellowish stone. South of Parkhouses a large fault throwing down north perhaps 600 ft. or more shifts the outcrop eastward. To the south of this there is a pretty good section in the Coalhouses Burn about Roughting Linn* opposite Shielhope, where the dip is 15° – 20° between S.E. and S.S.E., and there are sections in coarse sandstone south of the new road to Chillingham. There is a quarry in the Whinny Knowe near the Camps, but it is doubtful if this is not in the Tuedian series. The section shows:—

	Ft.
Sandstone: thick bedded and irregular, with a kind of parting below and breccia in places	$10\text{--}12$
Sandstone: very massive, yellowish-white	20
Shale, trace of, in the road to quarry—Dip S.E. at $12^{\circ}\text{--}15^{\circ}$	

East of Amersidelaw there seems to be another fault, throwing down north, but not so great as that previously mentioned. The sandstone forms a deep scarp to the west down to the edge of Robin Hood's Bog, where a very large fault with a downthrow north probably 1000 ft. shifts the outcrop a long way to the east, so that the base of the Fell sandstone on the south side seems opposed to the outcrop of the Main Coal on the north side. From this point the sandstone rises up to form the high ground of Ross Castle, the highest in the district, where the beds seem nearly flat, though further eastward the dip is clearly N.E., but beyond this in the same direction there is a good deal of drift, and as no coals have been worked the ground is very obscure. South of Ross Castle a large fault with a downthrow south of perhaps 1000 ft. shifts the outcrop westward again.

FOSSILS OF THE FELL SANDSTONES,

According to Mr. R. Howse.

PLANTÆ.

Ulodendron ornatissimum.
Lepidodendroid plants (Branches).
Calamite Stems.

MOLLUSCA.

Archonodon (Anodontia) Jukesii.

These were found in the quarry of Chillingham New Town.

In the Newcastle Museum Collection *Calymites scrobiculatus* is recorded from Newton near Chillingham.

Mr. Howse has kindly given us permission to reproduce his drawing and description of the *Archonodon* as follows:—

Description of a specimen of *Archonodon (Anodontia)*
Jukesii, Forbes, by Mr. R. Howse.*

On the accompanying illustration (Fig. 1) “a figure, *a*, is given of the largest specimen about [one-third] the natural size. The length when perfect would be about nine inches, and the breadth three inches and one-quarter. The anterior extremity is imperfect. The dorsal margin arcuated with slight indications of the umbones, before which there seems to have been a slight thickening of the shell. The hinge margin is slightly arched. The posterior margin slopes downward, and the ventral is slightly curved upwards under the umbones. The general form resembles the recent *Unio marginifer*, Linn., of our northern streams. The hinge line shows no trace of teeth, and was, as far as the preservation of these specimens shows, quite straight. The shell appears to have been very thin, as indicated by fine concentric undulations on the surface of the cast. There are no traces of muscular impressions. The smaller specimen (Fig. *b*) is more uniform in shape, which has partly arisen from the circumstance that it was resting in a sloping direction, with the ventral margin uppermost against the free margin of the larger specimen at *a*, and thus the free margins are compressed together and the original contour of the shell destroyed. The

* Extracted by permission from a paper in *Nat. Hist. Trans. Northumberland, Durham, and Newcastle-on-Tyne*, vol. 7, 1878, p. 4.

hinge-margin is also more slightly arcuated, the umbones more distinct, and the thickening between them and the posterior margin more defined. I hope shortly to give a fuller account of the geological position of the bed in which these shells were found. The generic term *Archonodon* is proposed for this huge freshwater bivalve."



FIG. 1. *Archonodon (Anodontata) Jukesii.*

CHAPTER IV.—CARBONIFEROUS—(*continued*).

SCREMERSTON COAL GROUP OR CARBONACEOUS DIVISION.

This division includes all the beds from the base of the Dun Limestone* the lowest workable limestone down to and including the lowest workable coal, generally called the Wester Coal, though the latter is a poor seam, or rather combination of seams, and little known in this district. Several of the coals have been worked in the neighbourhood of Biteabout, two miles south of Lowick, where the general section is:—

Dun Limestone—

	Ft.	In.
Measures -	60	0
<i>Fawcet Coal</i>	2-3	0
Measures	18	0
<i>Little Coal</i>	2	0
Measures, about -	165	0
<i>Blackhill Coal</i> , with bands	2	0
Measures	72	0
<i>Main Coal</i>	2	2
Measures, about -	150	0
<i>Cooper Eye Coal</i> , with band	2	0
Measures - - -	60-70	0
<i>Wester Coal</i> - - -	(?)	

Of course there are several small seams besides those enumerated, but it is not possible to give a detailed section of them. The total thickness, about 550 ft., is considerably less than at Scremerton in the map to the north.

The Fawcet Coal was formerly worked in pits on either side the road near Barmoor Red House, the deepest engine pit east of the road being 144 ft. In pits west of the road the Fawcet coal was 60 ft. below the Dun Limestone (4 ft.) and nearly all this thickness was sandstone. The coal was good, from two to three feet thick, and had a stone roof and a stone seat. The Little Coal worked on the west side of the road was from 24 to 26 ins. thick and was good at top. The outcrop of the coals makes a sharp bend round to the west and the Fawcet coal has been worked in Kemping Moss. It (or the Little Coal below) was also worked south of the moss, at the outlet of which a level was driven to drain the mines to the westward, but whether the seam is unbroken all across the moss is uncertain. Some distance south-west of the outcrop of the Little Coal at Biteabout, a pit 192 ft. deep has been sunk to the Main Coal, which has been worked about here for a long time. The shaft, at a depth of 120 ft., passes through the Blackhill Seam, which varies from two to three feet with bands. At a depth of 72 ft. lower comes the Main Coal, which is the principal coal worked at Biteabout.

* One of the beds of Limestone at Lowick, the Acre Limestone, is sometimes also called the Dunstone.

It is 2 ft. 2 ins. thick, and good. These coals bend round both to the east and west so as to give their outcrops the form of a horseshoe. The westerly dip of 12° may be seen in the burn to the south, west of the crop of the Blackhill Seam, and the easterly dip has been proved in the workings where the coals are cut off by a large fault which runs parallel to the road on that side. The Cooper Eye Coal has been proved in a trial pit 30 ft. deep, but it was too poor to work. The section was:—

Freestone roof—	
Top Coal	11 in.
Stone	8-9 in.
Bottom Coal	6 in.
Fireclay	6 in.

The Main Coal was proved on the south side of the burn in a shaft 30 ft. deep, but does not seem to have been worked there, and its outcrop to the west is uncertain.* A coal in two parts, with a band between them, said to be the Main Coal, was worked near the Ordnance Station, 516 ft., and a coal seems to have been found in a trial at Doddington Moor House. This is now said to be the Blackhill seam, and the Main Coal was proved in a pit to the south, but there are said to be troubles which render the coal worthless. The Biteabout fault, throwing down on the east, shifts the outcrops of the Blackhill and Main Coals to the south of the Coal Burn, and the Main Coal has been worked from the road eastward to the Hetton Coal Law Fault. The Blackhill seam is here poor, being only 12 ins. thick, and lying among shale, so that it has been little worked. The following is said to be the section of the beds above the Main Coal in some of the pits on Doddington Moor: it is a verbal account from memory:—†

	Ft. In.
Jingling post	6 0
Metal tills	3 0
Limestone	0 10
Metal	- 0 10
Coal	0 3
Limestone	- 0 6
Freestone bands	0 6
Black metal (swad)	0 6
Top Coal left on for roof	4 in.
Chalk stone	2-3 in.
Coal	18 in. } <i>Main Coal, about</i> 2 6
Chalk stone about	1 in.
Smithy coal	3 in.

At Coal Burn Houses a deep pit was sunk, but no coal got. It was probably just west of the fault. The deepest coal-pits here seem to have been these—one 108 ft. deep near the houses, and another 102 ft. deep further eastward. A fault that ranges about N.N.W. and throws down east 30 ft. was proved in the workings, and there is said to have been a "trouble" further east

* The Main Coal has since been worked here in a pit 120 ft. deep, and in shallower pits.

† I owe this and other information to Mr. John Brown of Biteabout.

at the place marked Doddington Colliery on the six-inch map. The Cooper Eye seam has not been worked here. It lies probably below the sandstone of Hare Crags.

The Fawcet seam has been worked from the Biteabout Fault round to Hetton Coal Law and a level was brought up from the Coal Burn. The crop may be traced like that of the Main seam by means of shallow workings and dayfalls.

The deepest pit in which it was worked is 150 ft. It is situated in a field north of the burn, and is 200 yards west of the Lowick road. The following is a verbal account:—

	Ft. In.
Sandstone mostly—	
Tills -	3 0
Dun Limestone	7 0
Coal	
Sandstone	
Tills -	2-3 0
<i>Fawcet Coal</i>	2 0

There is a pit 108 ft. deep by the roadside 300 yards north of Hetton Coal Law, which was sunk to the Fawcet. A little coal is said to have been also worked at Hetton; it was 18 inches thick and 18 ft. below the Fawcet.

The large fault throwing down south at Hetton Coal Law shifts the outcrop of the Fawcet westward about 1,100 yards, so that it is next found near Wrangham, where the coal has been a good deal worked. Here there are many old falls from surface workings, in some of which the coal could at one time be seen under red clay. North of the bog is a large pit, said to be 180 ft. deep, to which the following account probably relates:—

*Sinking account of the Doddington Engine Pit sunk by Andrew Scott.**

	Ft. In.
1. Freestone	108 0
2. Black metal -	3 0
3. Coal mixed with black metal-	0 2
4. Limestone	10 0
5. Grey freestone -	51 0
6. Roofstone : strong blue metal -	3 0
7. Clean coal (<i>Fawcet</i>) sometimes only 20 in.	2 +
8. Grey freestone	18 0
9. Coal	1 6

This is probably a verbal account and not quite correct. The limestone seems too thick for the Dun and there is almost always a coal below. I do not know if the coal at the bottom, 18 inches thick, was worked.

The dip here must be north-eastward, and is probably from 15° to 20° , judging by the sandstone at Wrangham below the coal. There is said to be a fault with a throw of 42 ft. crossing the coal before reaching the moss; it probably throws down on the north-west. Between the moss and Redsteads is a large fault throwing down to the south-east probably 150 to 200 ft.,

* From book lent by Rev. Hugh Taylor of Humshaugh-on-Tyne.

and shifting the outcrop 300 yards to the west. The Main and Cooper Eye Coals, &c., have not been worked near Wrangham, but a coal supposed to be the Main, and 2 ft. thick, was sunk to south-west of the moss; and below the wooded sandstone bank near the north-west end, a coal 16 inches to 2 ft. thick has been proved, which may be the Cooper Eye Seam. Coal also seems to have been found in an old level near this. Between the upper end of the plantation and Wrangham a bore-hole was made 38 ft. deep, but no coal was found.

South of Redsteads the Fawcet Coal has again been worked pretty continuously to nearly as far as Horton Moor House, but the lower coals have not been worked to the westward, though there are some trial-pits near the west side of the bog and just inside the Horton boundary.

To the northward of these is a quarry in yellow sandstone, false-bedded above, in which plants and shells are said to have been found.* Some of the massive whitish and brown sandstones to the west must belong to the Carbonaceous Series, but the lower boundary cannot be exactly fixed here. There are some small pits close to Horton Moor House, but what seam was worked is uncertain. The Fawcet Coal has been worked in another part of Horton Moor, to the west of the road and half-a-mile south of Horton Moor House. Between this place and the last-mentioned workings there must be a large fault, the direction of which is not exactly known, but seems probably about north-east. The deepest pit, about 650 yards west of the road, is said to have been 90 ft., but a pit only 48 ft. deep was sunk in 1870 to a coal 2 ft. 1 inch. The dip is nearly due north at 1 in 3, or about 20° , and the crop turns away northward at each end of the workings. To the southward, sandstone is seen with a northward dip of 15° to 20° . Another pit sunk to the same seam 200 yards from the road, was 66 ft. deep, and there is said to be a "trouble" between the two sets of workings.† Some borings were made to the south-west for the Main Coal, but were unsuccessful. Between these workings and Horton there may be another fault. At Horton, the Main Coal is said to have been worked in a pit close beside the stream, but nothing is known of its condition or thickness, and the continuation southward of these coals is very uncertain. They would seem to strike eastward about Horton, but they ought to be lying under the drift on the west side of the Till southwards from Fowberry Tower to the edge of the map opposite Chillingham. The coals here must lie in a synclinal, the western side of which dips to the eastward.

East of the Till, some of the lowest seams overlying the Fell Sandstones, crop out in the Dean at Chillingham Castle, but none of the coals seem to have been worked. They dip steeply to the west at angles of 50° to 60° , and are associated with shales and sandstones, and in one place west of the Castle is a limestone

* According to Mr. Stevenson, architect, Berwick-on-Tweed.

† For information about these Fawcet Coal workings on Horton Moor, I am indebted to J. G. Hargreaves, Esq., Durham.

18 inches thick with a coal seam a little below $4\frac{1}{2}$ inches thick. Coal is also said to have been got out in making a dam across the burn. The coals are not known in the obscure ground to the northward, but they probably occur west of the strip of Fell Sandstones, and have the same high westerly dip past Hetton Hall. Some of the beds of the series are exposed in a small burn that joins Hetton Burn on the west, to the north-east of Hettonlaw, but no coals were noticed. They are much obscured by drift north of Holburn Mill, and nothing more is known of them till Lowick Forest is reached, where some of the coals have been worked, *e.g.*, the Fawcet Coal and the Scremerston Main Coal or Blackhill Seam. These seams have been worked on the east side of the Low, opposite Lowick Low Stead, from near the main road southward for about three-quarters of a mile. The following is the general section to the Fawcet Coal from the Dun Limestone downwards :—

	Ft. In.
Dun Limestone	2 6
Coal, about...	1 0
Freestone bands, about	42 0
Fawcet Coal (15 in. to 29 in.) average	2 0
Stone seat	— —

The thickness of the Blackhill seam could not be ascertained, but one pit sunk to it was 120 ft. deep. The coals dip westward at 45° to 50° , and the crop workings end off southward before reaching Nagup Dean, where an apparently lower coal than either has been worked southward for 250 yards. This may be the coal exposed in a small burn east of the road opposite Lowick Low Stead. At the north end of the workings, not far from the cross roads, a fault throwing down N.W. 42 ft. was proved. The lower coals have not been worked to the eastward, though between this and the Whin Sill escarpment coal was found in draining the large field more than 50 years ago, and there is no doubt the Whin Sill itself is here in the Carbonaceous Series, and that some of the coals exist in the hollow south-west of the Kyloe Crags, among the sandstones, perhaps, even down to that of Dues Heugh to the north-east of Shepherd's Kirk Hill. A soft coal, 1 foot or more thick, was observed in a branch stream, west of the crags, 250 yards to the north-east of Lowick Forest House, and again in the hollow and stream south-east of the house, coal, perhaps the same bed, may be seen in more than one place, accompanied by fine sandstone with plant-remains. The sandstone of Colour Heugh Crags, massive, fine, and whitish, 30 to 40 feet or more thick, and dipping E.N.E. about 15° , appears to overlie the 1 foot coal last mentioned. Near the edge of Kyloe Plantation are quarries at Fine Hill, in massive, rather fine, whitish, and yellowish sandstone, which sandstone when traced westward seems to join on to that of Dues Heugh.

Just on the centre of the anticline, at Kentstones, the Fawcet Coal has been worked at a gin pit, and at other shallower pits, and there is also a coal below the Dun Limestone here, but I do not know if it has been worked. These coals are cut off south-

ward by the large fault throwing down north, which runs through Mount Hooly Dean. By it the outcrop of the Fawcet Coal is shifted nearly half-a-mile eastward, and then it appears to have been worked from the Dean southward to West Kyloe. I was informed by Mr. Hogg of that place that a seam of coal 2 ft. 6 in. thick, probably the Fawcet, was repeatedly cut through in draining a field immediately west of the road leading from West Kyloe to Kyloe Cottage. There is a thin coal seen in the road near the cottages, the outcrop of which runs a little east of the small burn. Some distance below the Fawcet Seam comes a thick sandstone which crops out in the Mill Plantation, and has been quarried in several places. At the southern end are seen 25 to 30 ft. of massive, yellowish stone, pretty fine, the upper part passing to the north-west into shaly and rubbly irregular sandstone, and the whole capped unconformably* by shales with irregular sandstone bands. Joints run 35 W. of N. Further to the north the dip seems 15° to 25° .

South of West Kyloe there is probably a fault throwing down south, and south of this the Dun Limestone and Fawcet Coal are not known, but they must lie between the Woodend Limestone of East Kyloe and the Whin Sill, approaching nearer to the latter as we proceed south. A thick sandstone with a gentle N.N.E. dip comes next to the Whin, to the south of East Kyloe. A coal was noticed in a field to the south-west of West Kyloe, just below the middle branch of the Whin Sill there.

By the large Kyloe Plantation Fault, which throws down on the south-east, all the beds on the north side are shifted far away to the west, the Fawcet Coal being carried to the south end of the plantation, where it seems at one time to have been worked in small pits north-east of the whin quarry. The lower coals are not generally known here, and some of them may not exist, their places being occupied by great masses of sandstone forming Rabbit Hill, 556 feet, Little Rabbit Hill, and Ravens Crag to the westward, though, as each of these forms a separate feature with a dip-slope to the north-east, there may be coals lying in the hollows. There is an old shaft 100 yards S.S.W. of the whin quarry, but no coal seems to have been found in it; this is opposite the west end of Shiellow Crags. Beyond the eastern end of the crags a soft coal about 1 foot thick, with much underclay, was noticed in the burn.

The Fawcet Coal seems to have been worked in pits close to Holburn Wood House and to the northward, its thickness being, it is said, 2 ft. 6 in. Whether the workings were stopped northward by a fault or whether they came against the Whin Sill is not known, but there is some evidence for a fault here, as the workings of the lower coal at Holburn Colliery do not extend beyond the west end of the moss, where it branches; but the fault may be small, and there is every appearance that the coals or some of them die out or are much thinner in a mass of sandstone.

* Local unconformabilities of this kind are not uncommon in the Carboniferous Rocks.

The coals have been worked at Holburn Colliery of which the following is a section of the last pit sunk in 1860:—

HOLBURN COLLIERY.

<i>Section of last Engine Pit sunk, August 1860.</i>	Ft.	In.
Freestone	36	0
Metal, coal and shale	7	0
Hard sandstone in 3 beds	3	0
Metal, coal and shale	4	0
Hard limestone	2	0
Metal	3	0
Hard whin sandstone, bad to bore	4	0
Metal and coal	2	0
Dark limestone	0	6
Metal	2	0
Dark limestone, bad to blast	3	0
Metal	2	6
Hard white limestone	1	6
Black and yellow shale (roof)	4	0
Top coal, fine best stony coal,	BLACK HILL or 1 ft. 8 in.	2 11
Hard metal, 5 in.		
Bottom coal, 10 in.	Scremerton Seam.	0 10
Metal		
Black band	0	4
	<hr/>	<hr/>
	78	7

The above is from a written account furnished by Mr. Henry Beattie of Chathill, Nov. 25th 1882. The shaft was near the old windmill shaft, just within Holburn property. The "hang" or dip was 8 inches to a yard.

The following account, continuing the section downwards to the Main Coal, is from the same authority, but is mostly from memory, no written account being forthcoming:—

	Ft.	In.
Hard sandstone	7	0
Sandstone, band and metal	2	9
Ten-inch coal	0	9
Metal and coal	about	6 0
Metal		
The hones (kind of oil shale)	- -	8 or 9 ins.
Measures, black metal, about		
Tough roof	<i>Bursting Bays Coal</i>	1 0
Measures (including 4 limestone beds near bottom, with a 3 in. or 4 in. coal) about		
Coal-parrot, 2 to 3 in.	Main coal, about	12 0
Fallen (kind of fireclay) 8 to 9 in.		
Coal, coarse, 8 in.		
Coal, fire coal, fine, 1 ft. 4 in.		

Total about 7 fathoms or 42 feet, making with the preceding, nearly 120 ft.

Mr. Boyd in his paper, "on a Part of the Carboniferous or Mountain Limestone series of North Northumberland,"* gives a section of the strata at Holburn Colliery, amounting to 117 feet

* Trans. N. of Eng. Inst. Min. Eng. Vol. IX.

total—so that he probably refers to the same sinking. We give the lower part of his section:—

	Ft.	In.
<i>Upper Scremerton Coal Seam</i>	2	6
Measures	22	0
<i>Bursting Bags Coal Seam</i>	1	0
Measures	18	5
<i>Upper Main Coal or Bulman Seam</i>	2	0

Several of the thin coals in the upper part of the pit-section are to be seen in the stream which runs out of the moss on the north side. The dip is to the north-east at about 15°.

The principal workings are in the Main and Blackhill Seams and these two coals have been worked southward for one and a-half miles or more down to the Cockenheugh Fault at Detchant Coal Houses. The small faults in the workings are given from the information of Mr. Beattie. The fault south of the burn ranges E.N.E. and throws down north 12 feet. Nearly half a mile south of the burn a group of nearly parallel faults crosses the outercrop of the coals. The most northerly of these throws down north 12 feet, the next and largest, which ranges nearly east and west, throws down north 42 feet, and the two most southerly throw down south 9 or 10 feet each. At the old Pit House on the map there was a pit 117 feet deep to the Blackhill Seam.

The sandstone at the top of the pit-section given, may be well seen on the south side of the Holburn boundary, and it forms a feature or bank in which are several small quarries to the west of Fawcet Hill, the beds dipping E.N.E. West of the south end of the large moss two other coals have been worked—probably the Cooper Eye and the Wester Coals—for a length of 500 yards or more in shallow pits. There seems to be a limestone above the higher of the two seams, judging from the heaps at the line of pits by which the seam was worked. The lower coal, which is said to have been in several seams, was worked from an engine pit, sunk near the south end of the workings just about on the crop of the upper coal. The Cooper Eye coal may be estimated to be 120 feet below the Main Coal, and the Wester Coal 60 feet lower. A line of pits down to the burn on the east shows that a level was brought up from it to drain the seam.

Mr. Boyd in his paper prefixes the term "upper" to the names of the coals worked here. He was under an erroneous impression that these were not the true Scremerton Coals, though called so by the miners, and he held the view that all these coals and the thick sandstones to the westward were high up in the Limestone series, coming above the Lickar coals and the principal limestones of Lowick.

The following fossils were collected by the Survey from old pit-heaps north of Cockenheugh:—Entomostraca (?), *Schizodus*, *Bellerophon*, and *Streptosulus*.

The coals are shifted by the Cockenheugh fault more than half-a-mile to the westward, and on the south side of this fault only one coal is known to have been worked, viz., the Cooper Eye, which was wrought near the south end of Girney Nick.

Plantation, three-quarters of a mile E.N.E. of North Hazelrigg.*
The coal here is from 2 ft. 6 in. to 3 feet altogether:—

Top coal, both good and bad	18 inches.
Band	several "
Bottom coal	7 "

Fossils collected by the Survey were—*Spirorbis helicteres*; and *Bellerophon (frugt.)*.

The dip to the north-east near the fault seems as high as 30°. The coal probably overlies southward the thick sandstone of Colour Heugh, below which may lie the lowest or Wester coal. The Main and other coals must crop out to the eastward, but are not known to have been worked, though a shaft between the two mosses may have proved the main coal. The dip is seen in several sandstone features to be to the north-east from 15° to 20°. The fault with downthrow south on the north side of Hazelrigg Moss shifts the outcrops about a quarter of a-mile to westward and south of this the Cooper Eye Coal has been worked as far as to the Old Hazelrigg road for a length of three-quarters of a mile. The section of the coal near the west end of the workings is:—

Roof, freestone bands.	
Top coal, with two thin chalkstones	18 inches.
Denty coal (swad)	12-15 "
Pure good coal	12 "
Bottom, tilly freestone.	

The Wester Coal probably underlies the fine sandstone-crag called Bowden Doors, which has many pot holes on its surface. Another coal has been worked here to the south-east of Hazelrigg Moss, which is either the Main or the Blackhill Seam. The following is said to be the section of it:—

Top coal	18 inches.
Band	20 "
Bottom coal	6-7 "

These coals are cut off before reaching the Lyham and Belford road by a large fault throwing down south, which brings against them on the south the Belford Moor coals which overlie the Woodend limestone, and the Scremerston coals must be shifted far to the west, but how far cannot be exactly stated as they have not been worked. In the upper part of the series here a sandstone has been a good deal quarried which would seem to lie between the Dun limestone and the Fawcet coal. The principal quarry is about 500 yards to the south-east of the main road, and west of the racecourse, and is called Rogue's Road Quarry. The dip is about 15° to the north-east but seems as high as 25° in places:—

Thin rubbly sandstone	4-5 ft.
Massive rather fine white sandstone	20 ft. or more.

There seems to be a coal below judging from fragments thrown out. This sandstone forms a pretty good feature for a long distance. There must be coals west of the moss that lies to the westward of this, and probably as far as the west side of the

* Information from Mr. Robson, of Belford.

Moss Ridge. There are several sandstone-features here which die out to the southward or are covered by boulder clay, but no coals have been worked till the large fault is crossed which throws down south at Chatton Colliery. Here again, owing to the throw of the fault the Scremerton coals on the north side must abut against the Woodend limestone on the south side of the fault, and the coals are shifted to the westward of Red Houses, where they have been worked pretty continuously for a distance of a mile or so. The following is the general section here, the total thickness being about 630 feet:—

	Ft. In.
Dun limestone	—
Coal	—
Measures	90 0
<i>Fawcet coal</i>	2 0
Measures	240 0
Limestone	3-4 0
<i>Blackhill seam</i>	—
Measures	50 0
Limestone	3 0
<i>Main coal</i> , with bands	2 6
Measures	175 0
<i>Cooper Eye coal</i>	3 0
Measures, about	60 0
<i>Wester coal</i> , in several thin seams.	

The Fawcet Seam has been worked north of the road across the Colliers Dean to the large fault, but has not been worked on the south side west of Linkeylaw Quarry. It is 2 feet thick and has shale above.

The Blackhill Seam has a limestone above it 3 to 4 feet thick. The workings in this seam are old, and the thickness is unknown.

The Main Coal was formerly a good deal worked, but mostly in shallow pits. The section of it as reported is:—

	Ft. In.
Freestones	6 0
Beds of blue and freestone blue (shale and sandy shale)	6 0
Limestone	3 2
Coal, with two bands	2 6

The Cooper Eye coal has been the most worked and some of the workings are comparatively recent. The deepest pit, which is 150 feet is nearly 200 yards due north of the bend in the road west of Linkeylaw Plantation.

*Section about Cooper Eye Seam** :—

Freestone bands.	
Dark limestone	8-10 inches.
Freestone bands.	
Dark limestone	8-10
Freestone bands, roof of coal	4-5 feet.
Top coal, divided into three beds by thin chalk stones	18-20 inches.
Swad or denty coal (will burn)	6
Bottom coal, good	1 foot.
Hardish seggar clay bottom.	
(The limestones are doubtful. The stone shown as a specimen is a hard bastard sandstone.)	

* For this and other information about the Scremerton Coals near Red Houses I am indebted to Mr. Murton, of Foulsteps.

North of Hayhill Burn and to the south-east of the guide-post, Mr. Henderson, of Chatton Colliery, sank a new trial pit 30 feet deep to the Main Coal, which was 18 inches thick, with many chalkstone bands, and had a thin limestone above it. North of the Bellshill road another pit 18 feet deep was sunk to the same seam, and here it was also 18 inches thick but without chalkstones. Further to the eastward a trial pit for the Blaekhill Seam was carried down about 15 feet but was stopped at a limestone 3 to 4 feet thick on account of water. The limestone is the roof of the coal seam. The Blackhill coal has been worked about this place and also to the north of Linkeylaw Plantation. The limestones which are associated with these coals are light coloured, sometimes nearly white, and contain plant-remains. *Solenya primæva* (?) was collected here from the Blackhill pits. The dip is eastward about the centre of the workings, and is probably at about 10° to 12° , changing to a direction south of east at a higher angle near Hayhill Burn, and to north of east at the north end near the large fault, where the dip is as much as 20° . Some distance west of the crop of the Cooper Eye, borings for the Wester Coal proved only several seams each 4 or 5 inches thick, and further westward borings were all in sandstone.

The large fault at the south end of these workings throws down to the north and shifts the outcrop of the coals far away to eastward beyond the moss north of Coalhouses. Here a coal said to be 3 feet thick, probably the Main Coal, was worked and drained by a level cut through the moss. Below Coalhouses two seams have been worked, the Main Coal and the Blackhill Seam, the latter having a limestone above it which makes a green band among the heather. Fish-remains are to be found in the pitch-heaps half a mile south of Coalhouses. Neither the Fawcet Seam nor the Cooper Eye appears to have been worked, and nothing is known of them. Borings just north of Coalhouses are said to have been all in sandstone, and were probably below the Cooper Eye. There are sections of some of the accompanying beds exposed in the burn south-east of Coalhouses: shale with sandstone, thin coal, and underclay with plants. The dip is eastward and varies from 6° to 20° , but is vertical in one place. The workings extend southward for $1\frac{1}{4}$ miles, when the coals are cut off by the Chillingham fault, which has a great downthrow north, and shifts the coals far to the eastward; but they have not been worked south of the fault and their outcrop is unknown. Another large fault with downthrow south at Ross Castle shifts the coals again a long way to the west, but out of this area, and there are probably other faults. The coals have been worked at Clattery, but before describing these workings it is as well to give a section* of the beds at Houghterslaw, which is some distance south of the edge of the Map.

* From *Miscellanea Geologica*, by G. Tate in *Proc. Berw. Nat. Club.* Vol. V. p. 284.

Strata at Houghterslaw, 2½ miles north of Bannamoor, near Eglingham, Northumberland:—

	Ft. In.
Clay thills, a thin limestone and shales	30 0
Coal 15 in. } <i>Crow Coal</i> , variable in thickness	4 0
Stone 24 in. } and poor in quality, not worked	0 6
Coal 9 in. } here	15 0
Shale	24 0
Sandstone, coarse at top but fine at bottom	0 6
"Grey beds," or slaty sandstones	3 0
White metal, with a coal called the <i>Ten Inch Coal</i> ,	
from 6 in. to	4 0
Hard sandstone	2 0
"Black beds," or calcareous shales	3 0
Limestone, bad	0 6
Greenish shale	1 3
Hard sandstone	Main Coal, viz., Top Coal 6 in. ; Metal Band 6 in. ;
	2 5
Bottom Coal 17 in.	<hr/> 89 8

The beds are disturbed but the general dip is north-east.

I obtained some information about the workings at Clattery from Mr. Christison of Houghterslaw. The uppermost coal of the above section is known as the Crow Coal, and it is said to have a limestone 4 feet thick above it. The section of this coal was:—

	Ft. In.
Top Coal, best	1 6
Midstone	0 8
Bottom Coal	1 0

This coal was found in the 13 fathom pits near Hangwell Law* but was in a very soft state there. It generally occurs about 8 fathoms above the Main Coal but was not found in the Clattery Pits. It seems probable that this seam is the same as that known further north as the Blackhill Seam or Scremerston Main Coal.

At the Clattery Pits the *Ten-inch Coal* is found about 16 feet above the Main Coal, and the section of the Main Coal and the beds immediately above and below is as follows:—

	Ft. In.
Dark stone, a kind of limestone in two beds	2 0
White metal	1 6
Grey stone	1 0
Top Coal 7 in. } Metal 6 in. } <i>Main Coal</i>	2 6
Bottom Coal 17-18 in.	
Freestone seat.	

The top part of the bottom coal is coarse. There is a chalk-stone 1 inch thick with an inch of coal between it and the stone.

This coal is now (1898) being worked in a pit 80 feet deep at Windylaw Colliery just inside the area of the map to the south.

The Clattery workings in the Main Coal are nearly continuous with those of Commonflat, which were probably in the same

* Within the area of the Map to the south.

seam. The dip of the coal varies but seems mostly to the E.S.E. as seen by the dip of the sandstones and shales in the Switzer Dean Burn. The Commonflat workings seem cut off by a fault which passes near Lanehead, and is probably a continuation of one proved in the area to the south. Just on the north side of this, south of Old Clattery, a seam of coal was at one time a little worked. It is said to dip steeply westward, and as a brown encrusting and coralline limestone was sunk through, the seam is probably the Fawcet Coal. The fault throws down on the north, and hence a coal worked to the south-west of Rosebrough may be the Main Coal repeated or a higher seam. The workings are very old and little is known of them. Where the crop of the coal approaches the stream in one place more than a foot of coal could be seen resting on shale, but this is probably only a part of the seam. The thin sandstones and shales below are seen in the stream westward of this, where the dip is E. at 10° . Probably there is another fault with downthrow north, between the outcrop of this coal and the Rayheugh limestone quarry.

A coal has been worked a little in the field close to and north of the cross roads at Lanehead, but nothing is known of it. It would seem probable that the sandstones and shales exposed in the Priestdean Burn to the eastward of Commonflat, and which dip at gentle angles to the east and north-east for a long distance, belong to the Carbonaceous Series.

There are also some small areas of the upper portion of the series to the west and north-west of Twizell House. That west of Twizell House is nearly a mile long from east to west. At the west end of the Quarry Plantation the Fawcet Coal has been worked in a range of pits running S.S.W. inside the plantation. The dip must be rather steep to the W.S.W., it is as much as 20° to 25° in the stream. On the east side of the area the same coal has been worked east of Brickyhirst, and northward between the South Dean and the Mill Dean, where the dip is eastward at angles of 5° to 10° . Between these two crops a considerable thickness of sandstones and shales lying below the coal is exposed in the main stream. The beds roll about a good deal, but on the whole form an anticline which is nearly flat about the centre of the Quarry-Plantation, where is a large quarry in massive white sandstone. To the west of this, 150 yards, a limestone about 2 feet thick is seen lying flat, though there are high-dipping beds between it and the large quarry. To the eastward, at the Washing Pool, shale and a thin coal and 3 inches of impure limestone are seen below sandstone.

A coal which is probably the Fawcet Coal has been worked at the North Wood, with a southward dip, but I cannot give its thickness. It is said to lie between two stones, and our informant stated that it came just below a blue limestone which was the roof of the seam, so that it may possibly be the Dun Limestone Coal. The Woodend Limestone is quarried to the southward, but the Dun Limestone is not exposed. To the eastward there are many old coal pits south of Hemphole Plantation and in the dean north of the Chuck Bridge, and the seam here worked is

probably the Fawcet, having an easterly dip, and underlying the limestone of Hemphole Plantation, which is probably the Dun. It is uncertain if the coal has an outcrop to the south-west or not. The workings are said to have been stopped a little north of the Chuck Bridge by a "trouble."

FOSSELS FROM THE CARBONACEOUS SERIES.

ANNELIDA.

Spirorbis helicteres, 29, T.

CRUSTACEA.

Entomostraca, 27.

Beyrichia arcuata.

MOLLUSCA.

Lamellibranchiata.

Modiola Macadami, T.

Leptodomus ?

Schizodus, 27.

Solemya primæva, 4 (ranges to No. 2 limestone).

Gasteropoda.

Bellerophon, 27.

PISCES.

Megalichthys.

Strepsodus, 27.

Fish remains, 5.

As the fossils from the Carbonaceous Series in this district are very few in number, it was thought advisable to give also those found at Deputy Row, near Berwick, in the area to the north of this. These appear without numbers in the above list. Those marked T. are also in the Tuedian. The numbers refer to localities which are enumerated in the general list of fossils (*Appendix*, p. 121).

CHAPTER V.—CARBONIFEROUS—(continued).

LIMESTONE GROUP OR CALCAREOUS DIVISION.

This group includes all the rest of the Carboniferous strata in this area from the base of the Dun Limestone upwards, the total thickness being about 1,500 feet. It is characterised by the number and thickness of its marine limestones, of which there are from 15 to 20 beds varying in thickness from a foot or two up to 30 feet or more. The number of coals that have been worked is also very considerable, but they vary a good deal both in quality and thickness, as will appear from the detailed description. The whole series as exposed in this district would appear in a section drawn from the dean north of Lickar in a S.S.W. direction, through Lowick to Barmoor Red House. The following section gives the thicknesses of the principal limestones of the series, together with an approximate estimate of the thicknesses of the intermediate measures:—

GENERAL SECTION OF THE LIMESTONE GROUP.

	Ft.
Measures with a thin limestone and the <i>Lickar Coals</i>	300
No. 1 or <i>Dryburn Limestone</i>	25
Measures with <i>Dryburn Coal</i> and a thin limestone	120
No. 2 or <i>Lowdean Limestone</i>	20
Measures	50
No. 3 or <i>Acre Limestone</i>	20
Measures with <i>Acre Coals</i> and a thin limestone	100
No. 4 or <i>Eelwell Limestone</i>	25
Measures with <i>Eelwell Coal</i> and others, and five or six thin limestones	- 300 to 400
No. 5 or <i>Oxford Limestone</i>	15
Measures with <i>Greenses</i> and <i>Howgate Coals</i> (several); also <i>Woodend Coal</i> and two or more thin limestones	- 300 to 400
No. 6 or <i>Woodend Limestone</i>	12
Measures	120
<i>Dun Limestone</i>	- 5

All the principal limestones, except the Dun Limestone, six in number, have been largely quarried and burnt for lime. Many of the old quarries are now nearly filled in with earth or are full of water. It was for lime-burning that many of the rather poor and thin seams of coal were worked.

The *Dun Limestone*, which was only 4 ft. thick at Barmoor, was 7 ft. in the pits near Hetton Coal Houses. It is a bluish-grey limestone which, owing to the presence of iron, weathers often to a brown colour, hence its name, but it is very little exposed in the western part of the area. In the Lowick Forest pits sunk to the Fawcet Seam, it was only 2 ft. 6 in. thick, and in this neighbourhood it is visible in the Low, and also in a small stream which joins the Low from the east, where the dip is 50° to west.

The beds between the Dun and Woodend Limestones seem to be principally sandstones, judging from the pit-sections and

from what is seen of these beds in the Coal Burn west of Hetton Coal Houses. West of Hetton Coal Law and south of Redsteads, these sandstones form marked features. No coal on this horizon is known.*

The *Woodend Limestone* is 12 ft. thick at the Barmoor quarry, and is generally a light-coloured or whitish limestone markedly coralline at top, where there is often a good deal of calcareous shale. By the Biteabout Fault it is thrown down to the south, and has been worked extensively east of Coalshank and in a long quarry at Hetton Coal Houses; but little is known of it or of the Dun Limestone to the south of the Hetton Coal Law Fault. The Woodend Limestone has been much worked at Chatton and Belshill, and many fossils have been collected from it, lists of which are given in the *Appendix* (pp. 88, 121). It takes its name from a place called Woodend in the Map west of this. Above this limestone the sandstone is often decomposed into sand. The Woodend Coal comes a short distance above the limestone, but does not seem to have been worked at Barmoor. At Hetton Coal Houses, however, a coal on this horizon has been largely worked, and is said to have been good. Further south in some more recent pits the coal was 20 to 24 in. thick, and reported to be a soft coal with a bad floor. The same coal seems to have been worked east of the Fawcet workings near Wrangham on the south side of the large fault there. It was being worked (1884) at Chatton Colliery.

Above this coal come sandstones and shales with the Little Howgate and Muckle Howgate Coals, which have not been worked at Barmoor, but one or both have been worked at Detchant Coal Houses, Fenwick and Belford Moor. The Muckle Howgate Coal has been worked south of Lowick in a pit 72 ft. deep, by the roadside about half a mile south of Brownrigg. The coal is rather dirty, with several bands, and is 4 to $4\frac{1}{2}$ ft. thick in all, the top coal being left on for roof, and only the lower 2 to $2\frac{1}{2}$ ft. being fairly good coal. West of the working-pit a series of borings, given in the *Appendix* (p. 136), proved the coal to range from 3 ft. 9 in. to only 2 ft. at the most northerly boring, and it would seem that further north, west of Brownrigg House, it was only 1 ft. thick in a boring made there to a depth of 90 ft. A thin limestone, 1 to 3 ft. thick, has been bored through above the coal, associated with white, green and red shales ("metal" in the accounts) which remind one much of parts of the Tuedian group. Similar beds are seen in the railway-cutting north of Scremerton Station, near Berwick, and again in the bay of the Burgess' Cove, north of the Tweed, where they have been mistaken for the Lower Carboniferous or Tuedian Beds. A lower coal supposed to be the Little Howgate, was proved to the west of the outcrop of the Muckle Howgate in a series of borings, details of which are given in the *Appendix*.

* Both Mr. Boyd and Mr. Tate in their sections give coals between the Woodend and Dun Limestones, and mention one of them as being worked, *viz.*, the Biteabout Seam, but this must be a mistake.

(p. 137). The coal in one of the borings occurred as in the following section :—

	Ft.	In.
Coal	0	11
Shale	1	5
Coal	0	6

The coal lies below a good thickness of red and white sandstone, but how far it is below the Muckle Howgate Seam cannot be exactly given. It must be as much as 50 ft., and is probably a good deal more here. It seems likely that this is the lower coal of the boring west of Brownrigg House, where it is 1 ft. 2 in. thick, and separated from the upper seam by about 53 ft. of measures. A boring further west below the coal proved nothing but red, white, and dun-coloured sandstone, to a thickness of 48 ft. 6 in., under 12 ft. of clay.

A thin limestone was noticed at Barmoor Clay Pit, and it may be seen in a small quarry to the north-west, on the other side of the road, dipping E.N.E. It is there blue and compact, and appears to be 3 or 4 ft. thick, but may be more. This I think is the same as the Watchlaw Limestone of the area to the west, and it appears in several other parts of this Map, being often light-coloured, like the Woodend Limestone. It is, perhaps, this limestone that was proved in the Brownrigg Borings. Higher up in this series of beds come the two Greenses Coals, proved near Barmoor South Cottage. The upper coal is 1 ft. thick, with 18 in. of limestone above. It is probably this coal that is exposed in the stream east of Barmoor Moss, where the following beds are seen :—

Dark shale.
Coal, nearly 1 foot.
White clay.

There are other two coals, thin, between this and the thick limestone above. One of the Greenses Coals has been worked a little east of Lowick High Stead, and a coal on this horizon has been worked at Low Lynn and Hetton Steads.

The *Oxford Limestone* is a grey or blue-grey limestone, often largely made up of encrinite fragments, and generally from 15 to 18 ft. thick. It has been extensively quarried near Barmoor Moss, west of Highstead Whitehouse, where it yields *Saccammina Carteri*, and there are large quarries in it at Dunsall in the area to the west and at Oxford, north of Ancroft, whence it derives its name. It has also been quarried north of Swinhoe and about Low Lynn, and it appears on the shore at Annstead, and twice at Monkshouse. In this district its outcrop is shifted eastward by the fault near Lowick High Stead, but there is little trace of the limestone in the drift-covered low ground south of Lowick. The Biteabout Fault shifts it back again to the southwest, and there is a small exposure of it north of Brownrigg, and a long old quarry in it north of the camp to the west of Laverocklaw, where it is said to overlie a thin coal. Another coal 15 in. thick, a few fathoms below, has been proved by boring. Again it is shifted a long way to the west by a large fault at Laverocklaw, and it is only seen once to the south of this, in a

quarry about half a mile W.S.W. of Hetton Steads; and south of this all definite trace of it is lost in the drift. West of the last-mentioned quarry the Greenses Coal has been worked; it was 20 in. in thickness with sometimes a metal parting 9 in. thick, the roof being a limestone 2 ft. thick. It seems there are two Greenses Coals here.

Above the Oxford Limestone comes a group of thin limestones with interstratified sandstones and shales with coals—the whole being 300 to 400 ft. in thickness. Of these limestones there are six to be seen at Scremerton, south of Berwick, and there would seem to be at least seven at Beadnell—but there are only traces of four or five between the Oxford and the Eelwell Limestones west of Lowick, and those are imperfectly seen. The highest of them is seen in the stream behind Lowick, and another was found in making the reservoir west of the village. Only one limestone is at all conspicuous and this is at the Cross Hills near Barmoor, where at the west end it becomes brown, and ends abruptly as if cut off by a fault. It may be the same limestone that is seen at the front of the houses at Barmoor. There are traces of some others in the fields.

In a little burn north of Brownrigg the beds are somewhat better seen, but still the section is rather a poor one. The following can be traced:—

Eelwell limestone.
 (Gap.)
 Limestone (?)
 (Gap: sandstone and shale further down).
 Limestone, brown.
 Sandstone and shale, dip 15° to E.N.E., of some considerable thickness.
 Limestone.
 Coal, underclay, and shale, seen in one place.
 Limestone.
 Sandstone and shale.
 Limestone, dip E.N.E. at 25°.
 Coal.
 Thin sandstone and shale.
 Limestone.
 Sandstone and shale, good thickness, with coal.
 Oxford limestone.

There is a better section north of Lowick in the stream near Low Lynn Mill:—

Eelwell limestone.		
Sandstone, seen for	- - - -	25 feet.
Limestone, thin, probably coal below	- - - -	5 "
Sandstone and shale, dip at 30° to W., at least	- - - -	100 "
Limestone, 8 to 10 feet	- - - -	9 "
Sandstone and shale	- - - -	40 "
Limestone, dip W. at 20°	- - - -	5 "
Sandstone and shale	- - - -	55 "
Limestone, dip W. at 20°, 7 to 8 feet seen	- - - -	8 "
Sandstone, seen for	- - - -	25 "
Limestone, 2 to 3 feet seen, say	- - - -	5 "
Sandstone and shale	- - - -	45 "
Limestone, thin, say	- - - -	3 "
Sandstone and shale	- - - -	75 "
		400 "

Oxford limestone.

The dip is pretty high throughout, and 400 ft. seems a moderate estimate of the thickness of the beds here. At Beadnell, the section of which will be given further on, they appear to be even thicker, quite as much as 500 ft. Only one coal is known to have been worked in this series near Lowick, and it occurs a little below the uppermost of the thin limestones, and is called the Eelwell Coal at Lowick, where it was worked south of the quarry. In one place where it was proved it was only 9 in. thick. At Beadnell there are two Eelwell Coals, one of them thick, and coals on somewhat lower horizons have been worked at Beadnell, Fleetham, and Hetton Steads. At the latter place, nearly half a mile west of the farm, a good coal has been worked 14 in. thick, or, according to another account, from 18 to 24 in. The workings are south of the large fault there, and the coal seems to be about half-way between the Eelwell of Hetton quarry and the Oxford, south of the Smithy; for two thin limestones can be traced in the fields east of the pits, and another seems to have been sunk through in the shafts.

The *Eelwell Limestone* has been extensively worked in a long quarry at Lowick, stretching for more than a mile to the westward, and the same limestone has been largely worked at Bowsden, Hetton, Beadnell, and North Sunderland. The dip in the quarry at Lowick is northward from 8° to 10° , changing to nearly eastward at the village, where it appears in the street. At the east end of the workings the section was—

Soil, like decomposed shale	2 to 3 feet.
Shale, becoming sandy above	18 to at least 24 , ,
Limestone worked, but one or two feet at the top not used	18 , ,
Limestone below not worked; only about 1 ft. of this at top is good stone	8 , ,

At the west end of the long quarry only about 12 ft. of shale is visible above the limestone. Near the middle of the quarry, where the road from Lowick makes a sharp bend to the north, there is about 23 ft. of shale above, with 2 to 3 ft. of flaggy sandstone near the top. Here is what seems to be a reversed fault with a downthrow of 2 to 3 ft.

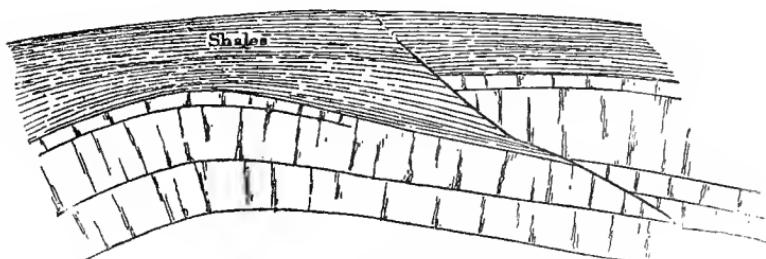


FIG. 2. Reverse Fault, Eelwell Quarry.

South of this is a fault ranging nearly east and west, throwing down south 4 to 5 ft. and having dun-coloured limestone along its course. A long list of fossils collected from this quarry will be found in the *Appendix* (pp. 86, 121). It seems to be the Eelwell

that appears in an old quarry between the two faults south-east of Lowick, and it can be seen in the stream some distance west of Moorhouse, but it cannot be traced southward. The large quarry at Hetton Steads, south of the large fault by Laverocklaw, is in the Eelwell Limestone. The dip is high near the fault—about 30° to E.N.E., changing further to the east to N.E. at 10° , and then to nearly due north, though the beds roll about a good deal in places. One of these sharp rolls striking N.N.W. may be seen nearly opposite the old limekilns, and others which may possibly be accompanied by small faults are visible nearer the east end of the quarry. Nearly opposite the old limekilns is the following section :—

Stony loam -	5 to 6 ft.
Tiles or thin flagstones about	6 " 7 "
Grey shale	10 " 12 "
Limestone	10 ft.
Shaly parting	7 to 8 in.
Limestone (bottom not seen)	4 ft.

Near the eastern end of the quarry 18 ft. of limestones were got out, leaving 2 to 3 ft. of bad limestone below unworked. The dip here changes again to N.E., but the limestone cannot be traced, being covered by 8 to 10 ft. of stiff blue till or boulder clay. The fossils obtained in this quarry are :—

- Lithostrotion junceum, *Flem.*
- Chonetes laguessiana, *De Kon.*
- Spirifera trigonalis, *Mart.*
- Productus giganteus, *Mart.*
- " longispinus, *Sow.*
- " sinuatus ?, *De Kon.*
- " spinulosus, *Sow.*

The beds between the Eelwell and Acre Limestones are not well exposed about Lowick. The following is partly an estimated section :—

Acre Limestone.	
Coal -	8 in. to 2 ft.
Fireclay	25 "
Sandstone and Shale - }	
Acre Coal with a 6 in. stone	20 in. to 2 "
Sandstone and Shale -	25 "
Little Coal.	
Sandstone and Shale -	20 "
Limestone -	5 "
Sandstone and Shale -	30 "
Eelwell Limestone.	

The coals have all been worked north of Lowick, and some of the upper beds may be seen along with the Acre Coal near Bar Moor Mill and in the stream east of Bowsden; but the best section is in the burn west of Moorhouse, where the limestone is exposed.

The coals were also worked for lime-burning at the Ancroft-steeds quarry at the northern edge of the map in a pit 90 ft. deep, of which the following is a verbal account :—

Tills	-	-	24 ft. 0 in.
Limestone	-	-	16 " 0 "
Freestone bands.			
Coal			
Bands -	-	-	2 " 6 "
Coal with 1 in. to 6 in. of Chalk-stone	5 ft. 6 in. to 18 "	0 " 0 "	
	3½ to 4 "	0 "	

In places the two coals nearly merge into one, and they vary much as to depth below the limestone.

The *Acre Limestone* has been a good deal worked north of Lowick at the Acres and west of the north road (where it has been called the Dun quarry, owing to its occasional yellowish or brownish tinge), as well as north-east of Bowsden, and at Linkey-lea and Ancroftsteads quarries. It is about 20 feet thick, and by some is reckoned the best limestone of the series. The bed has yielded many fossils at Lowick, Bowsden, and Ancroftsteads, the shale above being especially rich in *Ostracoda*, and the upper part of the limestone is in places full of the remarkable foraminifer, *Saccammina Carteri*. There is generally a bed of coal below the limestone, and this is said to have been 2 ft. in thickness at the Acres quarry, but it is generally only a thin coal. The shale overlying this limestone is in places rich in ironstone nodules.

The beds between this and the Lowdean Limestone are about 50 to 60 ft. thick, and seem to be mostly shales with some white and blocky sandstone near the top, and a thin coal immediately underlying the limestone. Some of the beds may be seen east of Barmoor Mill and in the stream west of Moorhouse, where they are flexured a good deal. They were also exposed in a new cut made there.

The *Lowdean Limestone* has not been so much quarried at Lowick as the others, but it is exposed east of Barmoor Mill, and there is an old quarry in it further eastward between the two roads running north. The thickness seems to be from 20 to 25 ft., but some of the upper part is thin-bedded and shaly, as may be well seen at the quarry in this limestone at Moorhouse, a mile south-east of Lowick, where were obtained:—

Phillipsia Eichwaldi, <i>Fisch.</i>	| Spirifera trigonalis, <i>Mart.</i>
Athyris ambigua ?, <i>Sow.</i>	| Streptorhynchus crenistria, <i>Phil.</i>
Productus longispinus, <i>Sow.</i>	| Terebratula hastata, <i>Sow.</i>

This is the limestone so much worked at Scremerston and on Holy Island. Lists of fossils from these places are given in the *Appendix* (p. 121).

The following is an approximate section of beds below the Dryburn limestone:—

Sandstone and shale	- 15 to 25 ft.	0 in.
Coal worked at Dryburn	said to be 1 "	3 "
Sandstone and shale	50 "	0 "
Limestone, gritty	6 "	0 "
Sandstone and shale	45 "	0 "

These beds are partly to be seen north-east of Barmoor Mill, and in the stream near Lowlynn Mill, and the coal, which has also been worked at Berryburn and at Newton-by-the-Sea, may be seen in several places in the burn south of the Dryburn quarry. There is a fair section of these beds at Lowick Mill, east of Lickar, where the strata between the coal and the thin limestone seem to be mostly beds of thick red sandstone.

The *Dryburn Limestone* is the highest thick limestone of the Calcareous series, and has been largely quarried for a length of three-quarters of a mile. It dips northward from 10° to 15° , in-

creasing to 20° or more west of New Dryburn, where it strikes away to the north-west, until cut off by the large fault there like the three thick limestones below and the Lickar Coals above. About 200 yds. east of the main road is the following section:—

	Ft.
Reddish clay above.	
Shale and thin sandstone bands, grey sandstone in middle and red above	15
Impure yellow-brown limestone, thin-bedded and shaly above	2-3 feet
Thick limestone post	3-4 feet
Shaly partings, with encrinites and brachiopoda	
Good limestone below in several beds, with a coral band near the top	7-8
Probably more limestone below.	seen to 12

Several caverns in the limestone have been formed at the junction of the upper and lower beds, and 200 yds. further to the east the beds are very much contorted into a series of sharp rolls something like those in the accompanying sketch:—

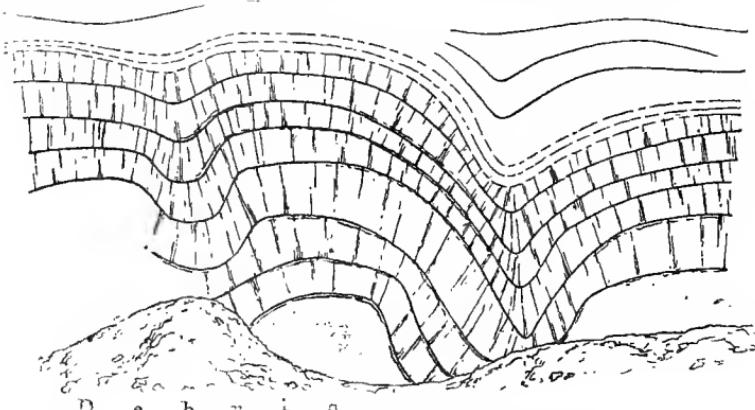


Fig. 3. Contortions in Dryburn Quarry.

The coals above the Dryburn Limestone have been a good deal worked from New Dryburn to Lickar and again west of Berrington. The deepest pits are from 180 to 216 ft. deep, but no satisfactory section of any deep shaft could be obtained. Most of the information about the workings was got from working miners. At Dryburn Colliery west of the main road, one shaft to the Lickar main seam was 204 ft. and another shaft north of this sunk for 216 ft. did not reach any of the seams, though the *limestone coal* was proved by boring 60 ft. further. The beds "hang" 1 in 1 or at about 45°, and the coals were won by a stone drift from the bottom of the shaft driven south-west for about 20 yds. The section* of the coals is as follows:—

	Ft.	In.
Limestone -	1	3
Coal -	15	in. to 2
Beds	8	ft. to 10
Rough coal, with bands	2	0
Beds -	8	ft. to 10
Main coal -	26	in. to 3

* Information from W. Brown, Bar Moor S. Cottage.

East of the road is a pit 150 ft. deep to the Lickar Main Seam. The following section of Dryburn Hill, Lowick, 1859, from *Sinkings and Borings* (issued by the N. of Eng. Inst. Min. Engineers), seems to be that of a pit about here, but I do not know how far it is trustworthy:—

	Ft. In.
Freestone, full of red keel -	126 0
Lickar Limestone	6 0
Coal -	2 0
Bandy freestone -	12 0
Blackband ironstone	2 0
Coal, rough	2 0
Freestone	13 0
Shale -	1 3
<i>Main Coal</i> , good, fine splint, but does not cake -	2 6

North of Old Dryburn there was an engine pit 96 ft. deep to the Main Seam. The section* of the coals here is said to be:—

	Ft. In.
Limestone -	6 in. to 2 0
<i>Limestone Coal</i>	18 in. to 2 6
Freestone bands and tills	6 0
<i>Parrot Coal</i> -	4 0
<i>Rough Coal</i> , with 2 bands in middle -	24 in. to 2 2
Freestone bands -	15 0
<i>Main Coal</i> , coarse, and not so good as rough coal	26 in. to 2 4

North-west of this the pits seem shallower, and the coals are said to turn up sharply to the north, probably against the large fault.

Mr. Steavenson's Lickar Pit, further to the east, was 180ft. deep to the Main Coal, but I could obtain no section of it. The following section of the coals given by Mr. Boyd in his paper was probably obtained from Mr. Steavenson when the pit was working —about 1860:—

	Ft. In.
Limestone -	4 0
<i>Coal</i> -	2 0
Freestone	6 0
<i>Parrot Coal</i>	2 6
Measures	6 0
<i>Rough Coal</i> -	1 8
Sandstone and Shale	15 6
<i>Main Coal</i> -	2 6

Another pit of the same depth, on the hill west of the house, is said to be sunk mainly through freestone bands above the coals; and in this direction the Main is said to become thinner and to deteriorate in quality, so that only the Rough Coal was worked. The Main Seam Coal was worked for land-sale purposes and is said to be highly bituminous in some layers, but leaves a residue of white ash.

More recently an attempt was made to work the coals further to the eastward, and Mr. John Dunn of Shotton Colliery sank a pit 400 yds. to the north-east of Mr. Steavenson's Lickar Pit. This was sunk to a depth of 126 or 147ft., and then a boring from

* Information from Alex. Bolton, Brownrigg.

the bottom proved the limestone seam 30 ft. lower, and others below that. There seem to be some discrepancies in the accounts kept of the sinking, so that the lower part is untrustworthy. The upper part is:—

	Ft. in.
Clay	12 0
Soft freestone bands	25 6
Blue metal	3 9
Freestone bands	9 0
Tills	9 6
Hard freestone post	11 0
"Blue" and freestone bands	7 6
Freestone post	10 0
Thick freestone	

The rest is not to be depended on, but seems to have been principally sandstone. The coals proved are said to be as follows (in a prospectus published in 1877):—

	Ft. In.
<i>Limestone seam</i>	2 4
<i>Cannel Coal</i> , same as <i>Parrot Coal</i>	4 0
<i>Lady Coal</i> , this is the <i>Rough Coal</i>	2 6
<i>Main Coal</i> -	3 6

Probably these thicknesses are somewhat exaggerated. Mr. Dunn sank another pit in the same field at the corner, near the branching—which was only about 55 ft. to 60 ft. to the Cannel Coal. The coals proved were said to be:—

	Ft. In.
<i>Limestone seam</i>	2 4
White post	3 0
<i>Cannel Coal</i> -	2 11
<i>Bottom Coal</i> , about	5
Band	10
<i>Lady Coal</i>	2 4

Most of the coals have come near together here. What has become of the Main Coal is not known, for a boring below the Lady Coal, though going down 27 ft. further, did not prove it. The boring was in:—

	Ft.
Hard white post	24
Soft red sandy shale	3

Some of the beds below the Main Coal, mostly sandstone, are to be seen in the stream north of Lowick Mill, dipping N.N.W. at 15°, and in the lower part of Dryburn, where a portion of the sandstone is coarse and red. Further west at Crookhouse is an old sandstone quarry where the dip is north from 10° to 15°, and the following section was obtained:—

	Ft. In.
Boulder clay	2-3 0
Coal trace, may be <i>Lickar Main</i> .	
Sandstone, thin bedded	2-3 0
Shaly coal	0 2-3
Dark sandy shale	0 9
Sandstone	3-4 0
[Gap of about]	1 0
Sandy shale, dark, with trace of coal	1 6
Sandstone white, and thin above, seen for	4 0

Some of the beds above the coals are visible north of Lowick Mill about the junction of the Low and the stream from Lickar Dean, and up the latter stream the dip is to the north-west and eventually beds probably higher in the series than any sunk through in the coal pits are exposed. There seems to be a great thickness of soft red sandstone, in places decomposed into sand, and this, in Lickar Dean, close up against the fault which passes along the north side of the stream, appears to dip at high angles to the south.

This Lickar Dean fault has a large downthrow to the south, so that all the beds of Lowick are repeated again to the north of it, from the thin limestones below the Eelwell up to the beds above the Lickar Coals, and probably nearly as far up as these soft red sandstones of Lickar Dean. In the dean it seems to be the Low-dean limestone on the north side that is thrown against these red sandstones, and the fault has probably a throw here of 400 ft. or more. The Eelwell limestone is seen in the village of Bowsden, and is quarried to the east of it; the Acre limestone has been a good deal quarried to the north of the burn, and the Lowdean and Dryburn limestones come on to the north, though they are not much exposed owing to a covering of drift. Yet a good deal of the Dryburn limestone may be seen down Berrington Burn past Berrington down to Berryburn Mill, and again at Berryburn itself. The Rough Coal and the Lickar Main Coal have been worked at Berrington in former times, but I could not learn much about the old workings, though I was informed that the Rough Coal was in a good state. The principal engine pit was situated south of the burn and about 100 yds. east of the main north road. The beds in the burn here dip generally to the west of north—but inclining to east of north in places—at various angles between 10° and 30° , and a bed of oil-shale or coarse parrot can be traced for more than 100 yds. on the south side of the burn. In the wood west of the road near the bridge are quarries in red and brown sandrock. This probably underlies the oil-shale and strikes north-eastward across the burn, dipping to the S.E. Immediately west of the bridge red and white sandstone is visible in the burn, and west of this is a good thickness of shale with two coals dipping a little south of east at 35° . There are some small coal-pits here and the two seams of coal may belong to the Lickar set.

There is now a gap in the section and then we see the following beds dipping at 45° to S.S.E.:—

- Shale.
- Soft massive sandstone.
- Shale.
- Shattered white sandstone.
- Coal, 6 in.
- Soft sandstone.

A little further west there is one thin limestone and probably another; and there is fairly good evidence, taking this and the sections further up the burn together, that we have to deal with quite a different set of beds, and that just before reaching the high dip of 45° , a large fault was crossed which throws down to the

south, the beds above the Dryburn limestone abutting against those below the Eelwell limestone on the north, for such seems to be the horizon of the beds about Sandyford Plantation. The beds are flexured a good deal and at rather low angles, and traces of coal appear in two or three places. About a quarter of a mile west of the bridge a pit was sunk about 60 ft. deep on the north side of the burn. The section is said to have been:—

Tills and freestone bands.
Bastard stone, neither freestone nor limestone.
Parrot coal, 6 or 8 in.
Coal, 1 ft.

It is possible that this may be the Greenses Coal, and a limestone may be seen in the burn close by.

There are traces of old pits north of this on the north side of the cross road, and coal brought out by moles was noticed further east in the same field. There is an old limestone quarry at the western edge of the Map near Berrington Law, which seems most likely to be in the Oxford limestone, and there is another old limestone quarry east of Berrington Back Hill which seems to be either in the Acre or the Eelwell. A sinking was made for water in a corner of the field 250 yds. north-east of the house, and this is an account of it:—

Soil and clay.
Sand.
Tills.
Coal, 20 in. or 2 ft.
Till.

This sinking was altogether 22 ft. and then a boring was made from the bottom 24 ft. further, which seemed mostly in tills; it was "soft stuff" according to my informant. The coal is probably the Acre or the Eelwell. The limestones and coals cannot be traced about here, however, as little can be seen at the surface owing to drift. South of the Ancroftsteads quarry, the Acre limestone, shale and sandstone are seen in the burn, dipping W.N.W. and N.W. at angles of 15° to 25°, so that there must be a fault or sharp roll between the burn and the quarry where the beds dip eastward. Some old quarries to the eastward, now full of water, show the Lowdean limestone, which is said to have below it a coal 1 ft. thick. Nearer Berryburn the Dryburn Coal was worked, and is said to be 16 inches thick. The Dryburn limestone is visible in the stream at Berryburn and for a long way below. A little south of the house it contains many corals, and some way north of the road there was found a large *Nautilus*. Further down stream the limestone is yellowish, compact and siliceous-looking, and is probably magnesian as it seems often to be. The limestone is folded a good deal in many places, and about 250 yds. south of Berryburn it rises out of the stream and exposes sandstone below, which near Berryburn Mill is faulted against the same limestone.

There are limestone quarries on both sides of the stream at Bridge Mill, in rather compact blue limestone, apparently nearly flat, but what bed this is I cannot say. All the ground to the south around New Haggerston is thickly covered with drift, and

nothing is known of the rocks below. Some of the limestones and associated beds above the Oxford appear however in the Low to the south-east, with a north-west dip, and the Oxford limestone itself is in the stream east of Lowlynn Bridge and it has been a good deal quarried near Lowlynn and southward over Kentstone Hill. At one of these quarries by the roadside 1½ miles W.S.W. of Beal Station were collected:—

Alveolites.
Orthis Michelini, *L'Eveillé*.
Productus longispinus, *Sow.*
Spirifera trigonalis, *Mart.*

The Greenses Coal has been worked on the hill and in the field to the south, and there are also many old pits and falls at Lowlynn, showing that it was worked there. At High Kentstone there is a well-marked sandstone below this coal, but not much is seen of the beds west of this down to the Wood End limestone, though there is in one place a trace of one of the Howgate Coals and the Woodend coal seems to have been worked east of Kentstone. Little is seen of the Woodend limestone except in two small quarries, but some of the beds below it are exposed in the side of the whin quarry south of Kentstone, where sandstone and shale dipping eastward from 8° to 30° are altered by the dyke. The Dun limestone appears at the bend of the road a little north of the fault, and it has a coal immediately below. The Oxford limestone bends round on approaching the fault and runs along the north side of Mount Hooly Dean with a northward dip till cut off by the fault; and a part of it appears again close to the fault at Mount Hooly, apparently with a high dip to the north.

Beal and Fenwick.—The Eelwell Limestone is found on the shore at Beal Point, dipping eastward at 5°–10°. There is a line of crush with spar in it running eastward. Several quarries in this limestone occur in the fields to the south, and it appears to be the same limestone that is found at Fenham Granary, where there is an old quarry. In the cliff southward from this is found a considerable thickness of dark shale with ironstone nodules, and this probably overlies the limestone. A list of fossils collected at Beal Point will be found in the *Appendix* (pp. 86, 121).

Along the shore west of Beal Point several thin limestones are found. The first to be noticed is a brown impure limestone with caudagalli markings. It has a good coal about 1 ft. thick below, and this rests on a fireclay. Two or three other limestones are to be seen near the mouth of the Brockmill Burn, the uppermost of which has been quarried in the fields to the south. Another limestone, which may be the Oxford, crops out at the farm-steading on the east side of Beal; and on the west side of the hill is a large quarry in fine white sandstone dipping gently to the east-south-east.

Much sandstone is found outcropping about Fenham Hill with a gentle southerly dip, and south of the fault at Mount Hooly with an east-north-east dip, and many sections in shale and sandstone occur in the sides of the whin dyke quarries, especially in Cockleman's quarry.

At least two and perhaps three coals known as The Howgate Seams are found on the south side of Mount Hooly Dean. In a level driven westwards from the dean the most easterly and uppermost seam was found to be 1 ft. thick. The same coal burnt to a cinder is visible in Cockleman's quarry. A limestone 4 in. thick was found below in the level. The lowest seam, with bands, is 2 ft. 8 in. thick. The same coals occur at Fenwick, where one engine pit 120 ft. deep was said to be sunk in a fault which throws down the Small Coal, 42 ft. above, so as to be opposite the Lower Coal. This engine pit at the west end of the village is now a saw mill. The following is said to be the section of the Lower Coal :—

	Ft.	In.
Black metal, soft	13	0
Top coal -	2 in.	
Soft metal	8 in.	
Top coal	8 in.	
Chalkstone, bright yellow	$\frac{1}{2}$ in.	2
Coal	14 in.	$1\frac{1}{2}$
Brown slate	3 in.	
Thill, white marl, like seggar -	2	0

A boring below this to the extent of 54 ft. was all in freestone.

The light-coloured Woodend Limestone crops out in the dean between West and East Kyloe, and may also be observed in several quarries near the latter place. Both it and the Dun Limestone below are probably shifted by the faults which affect the Howgate Coals. In the fields east of Fenwick a brownish siliceous-looking limestone may be noticed in several places between Fenwick Granary and Fenwick Stead. This is probably the Watchlaw Limestone of the adjoining Sheet 110 S.W. The whole of these beds are cut off by the great fault which passes south-west through Fenwick and Kyloe Woods, and has a downthrow to the south-east. The limestone once worked at Fenwick Stead is probably one of the higher limestones (Eelwell or a higher one) faulted on the east against a thin grey and brown compact nodular limestone, a little below which a coal seems to have been wrought. There is much disturbance in the rocks of this neighbourhood. At the north-east end of Kyloe Plantation a coal was wrought, said to be 1 ft. 6 in. thick, a dirty seam, only fit for lime-burning. Nearly half a mile south of this and a quarter of a mile east of the wood is a large old quarry where the Oxford Limestone was worked for lime-burning. There is 15 ft. of dark shale to be seen above, and the dip is from 15° to 20° or even more, to north-east. Between this and the coal last mentioned, four limestones crop out, of which the upper two have been quarried. They all dip N.E. and overlie the Oxford Limestone. A coal has been worked south of Buckton where the beds dip to the north-west. There are numerous sections along the County Burn in shales and sandstones with a thin limestone, but all seem below the Oxford and above the Woodend Limestone.

Belford.—In approaching the Belford district from the north, we find that the Woodend and Dun Limestones have been quarried near Holburn Woodhouse on the west side of

Detchant Wood; and a coal has been worked on the east side of the same wood near the Woodhouse, which has the following section:—

	Ft. In.
Coal, soft, dirty	6 in.
Coal	3 in.
Shale	4 in.
Coal	5 in.

The beds rest on shale and dark micaceous sandstone 2 ft. in thickness, and fine sandstone is found below. The dip of the beds is here to the north-east and east-north-east at angles of 6°–10°. To the westward sandstone is found, and then shale with two thin limestone bands from 12 to 18 in. each. In the branches of the next burn to the south-east of the Woodhouse a poor coal is found, 15 in. thick, which is probably the same as that last described, and one of the Howgate Seams. It occurs among undulating sandstones and shales.

Nearly a quarter of a mile to the south-east of the last-mentioned burn a limestone has been quarried. The position of this is uncertain. It may be the Oxford Limestone. A compact blue limestone, probably the Dun, has been quarried more than half a mile to the west near a place—not on the map—called the Grey Mare. It is said to have been from 6 to 9 ft. thick, and was quarried under 12 ft. of tills and 10 ft. of soil.

The rocks are now shifted a long way to the south-west by the Cockenheugh Fault, which has a large downthrow to the south-east, but does not appear to affect the Whin Sill, and is therefore probably older than the intrusive rock. The Oxford Limestone appears to have been quarried 100 yds. south of Swinhoe Pond; and nearly half a mile south of Detchant Coal Houses, the Dun Limestone has been extensively quarried. It is at least 7 to 8 ft. thick, is of a blue-grey colour, weathering-brown, and is said to be 10 ft. thick and to have a 9 in. coal below. Above it comes 10 ft. of shale, and over this soft white sandstone up to 10 ft. The dip is north-north-east to north-east at 10°–15°. Names of fossils collected here and at the Grey Mare will be found elsewhere (see pp. 89 and 121). A coal which is above the Woodend, and is probably one of the Howgate Seams, has been worked west of Dick's Old Walls between the two faults marked. Below this in places, the beds have a high dip of 40°–60° to east-north-east. To the east of the fault the same coal has been worked near Middleton Tile Works, and west of Plantation Farm up to the fault near Blagdondean. In a pit 600 yds. east of the tile-works there are two seams, but only the lower of the two was worked. The most important part of the pit-section is the following:—

	Ft. In.
Parrot coal	2 0
Beds - -	18 0
Coal { Top coal	18 in.
Band -	20 in.
Bottom Coal	7 in.

The Parrot Coal probably represents the Oil Shale of other pits. Near Plantation Farm the coal was 2 ft. 3 in. to 2 ft. 5 in.

thick and dipped to the north-east at 1 in 5. There are many old shafts in the Coal Wood, and one of these south of the house was said to be 144 ft. deep. A coal has also been wrought half a mile to the west in a curved outcrop just north of the Blagdon-dean Fault.

South of this fault there is a good section in the Blagdon-dean. The flaggy sandstones and thick bed of shale overlying the Oxford Limestone have a gentle dip eastward of 3° to 5° . The limestone has been largely quarried on both sides of the dean and probably also near the Guide Post east of Sionside. Below the limestone in the dean is a coal 8 in. thick which rests on grey sandy underclay. To the westward crop out thick sandstones, and below them the Greenses Coal has been worked. The dip is here about north-east. Two other coals have been tried a little to the west; and near the north end of the racecourse on Belford Moor are two more coals, making in all five that have been here worked between the Oxford and Woodend Limestones. Of the racecourse coals, the upper, called the Little Coal, is 18 in. thick, and the lower, called the Stony Coal, has a freestone roof, and the following is its section:—

	In.
Top coal -	18
Band -	20
Bottom coal	6-7

This seems to be the same seam as that near Plantation Farm, shifted a mile to the westward by the Blagdon-dean Fault. The Woodend and the Dun Limestones have not here been quarried.

The Stony Coal appears to be that worked near the southern end of the racecourse, where there are several faults. It is 18 in. to 2 ft. in thickness. Again it has been worked further south, and close to the large Belford Moor Fault. Two seams have been worked at the latter locality, the lower of which is the Stony Coal. The Top Seam is here 15 in. to 18 in. thick, and is a good coal. Below are 6 or 7 fathoms of strata, and then comes the Lower or Stony Coal, made up of three beds:—

Stony coal	Tops	18 in. to 2 ft.
	Metal	18 in. to 2 ft.
	Coal	8 in. to 2 ft.

In the pit-heaps of the upper seam an oil shale is found, which seems a constant band in North Northumberland.

On the east side of the fault here a limestone has been worked, which is white in colour, and is probably the same as that seen in Newlands Burn north of Whitelee. It is the Watchlaw Limestone of Sheet 110 S.W.

A coal 16 in. thick was worked in pits in Warenton Dean, but the same coal thickens in places and was found to be nearly twice this thickness in one shaft 60 ft. deep, of which the following is an oral account:—

	Ft.	In.
Surface -	6	0
Dark grey limestone	3	0
Freestone bands and blue mixed	18	0
Freestone in thin beds	15	0
Blue - - - - -	18-20	0
Coal - - - - -	2	6

There was no regular band in the coal, but sometimes it contained round sulphur stones or 'brassy.' The bottom was a hard blue till.

A still lower seam than any of the above has been extensively worked for lime-burning and household purposes at Chatton Colliery. The working pit in the year 1882 was three-quarters of a mile west of Warenton, and was 120 ft. deep. The coal-section was as follows:—

	Ft. In.
Hard post, roof stone	5 0
Coal	1 6
Band -	1 8
Coarse coal -	1 0
Freestone bottom.	

The dip is eastward at 1 in 7.

In a pit farther south the coal-section was as follows:—

	Ft. In.
Top coal	1 4
Band -	2 0
Bottom coal -	1 0

Here a "trouble," occurred which seems to have been only a 'nither,' for the top coal continued on, though the bottom coal entirely disappeared. The line of thinning had a direction from east to west. In 1848 an account of the seam worked on the north side of the road gives the section as:—

	Ft. In.
Roof, blue metal.	
Coal	1 ft. 2 in. to 1 3
Soft metal	- 3 0
Splint coal	1 ft. 6 in. to 1 8

This seam is the Woodend Coal and it occurs here from 9 ft. to 15 ft. above the Woodend Limestone. From the pit-heaps north-east of the lime-works were obtained the plants *Cardiopteris polymorpha* and a species of *Sphenopteris*.

The Woodend or Chatton Limestone is 13 ft. thick, light-coloured and coralline, and often the upper part is a calcareous shale crowded with corals. Sandstone often rests almost immediately on the limestone, being thus an exception to the almost universal rule that shale overlies limestone. A fault with a down-throw south, nearly along the line of road, appears to cross the coal-workings and both the limestones here quarried. The Linkeylaw Limestone (the Dun) has been largely wrought for road metal. It is a compact grey rock, weathering of a brownish colour, is 7 to 8 ft. in thickness, and has been quarried under as much as 20 ft. of shale.

The Woodend Limestone has also been much worked at the Belshill quarries east of Mousen, where it dips gently to the south and spreads over a considerable surface, though at the east end near the main road it turns sharply round and dips steeply eastward. This limestone is 12 ft. thick and below it is an impure limestone 6 in. thick, which rests on a fireclay, beneath which comes a mass of false-bedded white and yellowish sandstone more than 20 ft. thick. (For fossil lists from all these quarries see Chapter VI. on Palaeontology.)

Over a large area to the south and east of Belford very little solid rock is exposed, and to the north and north-east of the town all the prominent features are formed by the Whin Sill. Much of the country is obscure, though a few of the higher limestones have been quarried.

A limestone, which is probably thin, was observed in the fields north of Belford Station, and in the Chesterhill Dean, where the road crosses, a red limestone may be seen which has probably furnished the red fragments found in places in the drifts, and which have been by some supposed to have come from Scandinavia. Lower down in this same dean, and overlying the limestone, is a mass of shale with thin irregular sandstone bands, altogether some 20 ft. thick, and above this comes 6 ft. of flaggy sandstone. There were collected here *Athyris Roissyi*, a fragment of a *Lingula*, and *Streptorhynchus crenistria*.

To the north-west of Belford on the north side of the Blagdon-dean Fault we find the Oxford Limestone at Craggyhall shifted nearly a mile eastward by the fault. About 7 ft. of dark compact encrinital limestone may be observed, but this is probably only one-half of the total thickness. It has 10 to 12 ft. of shale over it, containing small ironstone nodules. Traces of one or two other limestones are found to the north of Sunnyside Hill, and in one place there is a patch of limestone adhering to the whin on the hilltop. Shales that underlie the whin have been found on the north side of Belford in drains and wells.

The limestone quarried at Middleton is probably the Eelwell, but the section there is much complicated by the irregular intrusion of the Whin Sill, which has altered the rocks considerably, rendering the limestone crystalline. In the quarries west of the main road the limestone appears to be about 18 ft. thick and patches of limestone are enclosed in the whin which sends out dyke-like processes. One of these, 2 ft. in width, runs westward through the limestone on the north side of the old round quarry, now a pond, and another dyke crosses the stream to the west. On the east side of the road whin occupies the bed of the stream for 70 yds. from the bridge, and to the northward is a large old quarry in the limestone. On the south side of the stream we see a section in beds which overlie the thick limestone:—

Limestone, forming small outliers, 1 to 2 ft.
Coal.
Thin sandstone and shale, 5 to 6 ft.
Sandstone, fine and white above, reddish below.

The lower part of this section is truncated westward by the rising of the upper surface of the whin.

A north-west fault probably crosses the stream 130 yds. from the road, and east of this sandstone occupies the stream. Overlying this comes a limestone with a dip of 8° to east-north-east, possibly the same limestone as that worked near the road, and into which the whin is intruded. From the outcrop in the stream limestone may be noticed at intervals to the south-east, till we arrive at the large quarries near Easington demesne where the

bed dips north at a gentle angle and covers a large surface. The following fossils were collected here:—

- Cyathophyllum Murchisoni, *M. Edw.*
- Poteriocrinus (stems).
- Orthis resupinata, *Mart.*
- Productus giganteus, *Mart.*
- Spirifera trigonalis, *Mart.*

The limestone is largely encrinal, dark blue in colour, and is succeeded northward by shale which overlies it. It is probably a portion of this limestone that appears west of Easington below the whin of the hill. A limestone has been largely quarried north of this at Easington Mill where the rocks are sharply folded and the structure is difficult to make out; and the top of another or the same limestone appears at the east end of the mill-pond coming up as a dome. In the quarries were collected:—

- Chonetes laguessiana, *De Kon.*
- Productus pustulosus ?, *Phil.*
- scabriculus, Mart.*
- Posidonomya Becheri, *Goldf.*
- Bellerophon Urei, *Flem.*

Another limestone with a north-north-east dip of 60° appears at the farm-steading at Elwick, but sandstone only was found in two wells sunk near the house.

An extensive series of borings, details of which are given in the Appendix (p. 134) was made on this farm, but no valuable coal-seam was found, though one of the borings was more than 120 ft. Some limestones were met with, however, and one of these was $15\frac{1}{2}$ ft. in thickness, but none of these crops out at the surface, the soil and clay overlying them varying from 8 ft. to as much as 32 ft. thick. About two-thirds of a mile north-west of the farm there was formerly an old coalpit, of which the following is an account:—

	Ft.
Clay, with boulders	32
Soft pale blue metal	12
Black metal	1
Coal	2
Black metal	2
	<hr/>
	49
	<hr/>

Warenford district.—The principal sections about Warenford are afforded by the Waren Burn from Lucker upwards. None of the higher limestones are known in this area. At Lucker station a boring for water was made to a depth of $107\frac{1}{2}$ ft., and the strata pierced were:—

	Ft.	In.
Clay and sand	13	5
Soft post	10	9
Strong hard post	18	6
Blue metal	11	4
Hard grey post	38	10
Grey metal	7	11
Very hard limestone with a little spar in it	6	9
	<hr/>	
	107	6
	<hr/>	

A limestone has been quarried about half a mile west of Lucker village, which is said to be 8 to 12 ft. thick, with a coal below. A few feet of shale may be seen at the top of the quarry. The limestone may be the Oxford, and it is probably bounded on the south side by a large fault. There were collected here: *Alveolites septosa*, *Cyathophyllum*, *Lithostrotion Portlocki*, and *Productus*. Sandstone of various colours, dipping to the north-east, occupies the stream at the village, but higher up, the sandstone undulates and the dip is in various directions. Three hundred yards above the mill-pond a thin impure limestone occurs of which 2 or 3 ft. may be seen. The dip of this is to the north-east, and it is succeeded by shale and sandstone, and 600 yds. farther up by another limestone which seems a thicker bed. It is of a blue colour, at least 5 ft. thick, and has been quarried in the banks of the stream, where 5 ft. of shale overlies it, and over this is sandstone. Below this limestone, sandstone with a north-north-east dip of 6° to 7° succeeds for some distance, and under this lies a coal which has been worked in many shallow pits on the north of the burn. Thin sandstone with plant-remains, and an 8 in. limestone lie below the coal. Soon the dip increases considerably, and there is probably a fault crossing the stream in a direction a little north of west. It appears likely that all the beds north of this fault belong to the series of thin limestones, &c., above the Oxford Limestone. However this be, it is certain that the rocks now to be described, which occur south of the fault, are below that Limestone.

On the south of the fault the sandstone has an easterly dip of 20° to 25° , and there appears a coralline limestone two feet in thickness. Another limestone occurs rather more than 100 yds. higher up the stream, and this is white, fine-grained, and blocky, and dips east at 10° . Near the foot-bridge the beds are nearly horizontal, and higher up the dip eastward is only about 5° , in whitish, yellowish, and greenish micaceous sandstone. Opposite Warenford, sandstone may be seen in places, and above the bridge fine sandstone with a northerly dip occurs. A little above the junction of the two streams we come on the Woodend Limestone in the South Dean, but in the North Dean the outcrop of the bed is considerably further up owing to the dip being here to the north-east. It is just beyond the sharp bend in the stream, where we find the section to be:—

	Ft.
Thick bedded sandstone	12-15
Thinner sandstone	6
Shales	7
Grey limestone (Woodend).	

Proceeding up the North Dean we come on to the beds below the limestone, and 350 yds. higher up there is a fine section in Corbie's Crag of nearly 40 ft. of sandstone with 7 ft. of shale below. A hundred and fifty yards farther west we find the Dun Limestone, blue-grey in colour, and at least 6 ft. thick, in three beds, with a north-east dip of 10° . The beds for about a mile west of this belong to the Carbonaceous Series, and have been described previously, see p. 29. The Dun Limestone, with a

steep dip to west, appears again in a poor section at the sharp bend of the stream west of Quarry Plantation. The sandstones and shales in the stream about Luckernoor house, which dip first west and then north, may belong to the series between the Dun and the Woodend Limestones, but it is more likely they are a lower set brought up by a concealed fault. The Woodend Limestone has been quarried to the west near Brownridge, where it is a white limestone dipping east and south-east at angles of 10° to 15° ; it has 10 ft. of thin shaly sandstone above it. It has also been quarried to the west of Twizell North Wood, where the sandstone above it is coarse, and reddish in colour, but in neither locality does the Dun Limestone appear. A thin nodular limestone is visible by the side of the Warenton Burn, south of Warenton, and nearly 200 yds. south of the Belshill road. It is probably one that lies between the Woodend and the Oxford Limestones.

A limestone has been quarried at the cross roads about 600 yds. south-west of Newham New Buildings, and north of Ellingham. This limestone is either the Dun or the Woodend, and the sandstone and shale with a south-east dip, visible in the burn about here, should overlie the limestone. Sandstone with an easterly dip, crops out in several places in the village of Ellingham, and two-thirds of a mile west-south-west, a thick sandstone, which has been quarried, makes quite a feature with a scarp to the west.

By the roadside north of Lanehead is a rather large and deep quarry in a thick-bedded, fine, yellowish sandstone, which is nearly flat, or gently dipping to the south-west.

The position of the Rayheugh Limestone in the series is somewhat uncertain. It is 7 to 8 ft. in thickness, compact and encrinital, grey in colour above, but darker below. Shale or clay lies below it, and 4 ft. farther down a coal is said to occur. Sandstone crops out not far above the limestone.

There is a limestone at a place called Hot Law, on the south side of the long plantation, more than three-quarters of a mile west of Rosebrough. A small quarry has been dug, but the limestone was said to be in a disturbed state, and the quarry was given up. Some four or five feet of blue-grey limestone could be seen, but judging by the hole made, it is probably much thicker. The dip seems to be S.W. or W.S.W. at a high angle (55°).

Chillingham.—In the Chillingham synclinal, before described, both the Woodend and the Dun Limestones must be found, but the former only has been quarried. The old quarry in it is west of Chillingham Barns, but it gives only a poor section, about 2 ft. of light coloured rock being visible. To the west, a sandstone which comes between the two limestones has been quarried. The dip is easterly in both quarries. I was informed by Mr. Bowie, of Chillingham, that a limestone was found in the Limetree Drive, about 50 yds. from the West Lodge; and limestone was also ploughed up in a field to the north-west of the Lodge. These would be on the east side of the synclinal.

Nearly two miles E.S.E. from Chillingham a small area of limestone is coloured just at the edge of the Map on the south

side of a large fault. Limestone, however, is not visible here, but the strip is the continuation of the Woodend Limestone, which has been quarried at Botany in the area south of this.

THE EAST COAST AND THE ISLANDS.

Beadnell.—The best and the most complete section of the limestone series within the limits of this Sheet is to be found on the shore at Beadnell, from the harbour northwards to Annstead, a distance of a mile and a half. Unfortunately it is not complete in the lower part, as we do not see the Woodend and the Dun Limestones along the shore. They are found, however, inland near East Fleetham. The shore sections display all the limestones and intervening beds from the Ebb's Snook or Dryburn Limestone down to the Oxford, or rather, down to a thin limestone, 4 ft. in thickness, which lies 20 ft. below the Oxford Limestone. A few faults occur in the section, but these are small, and do not offer much difficulty in making out the succession of beds, which will be found to differ considerably from that given by Tate* and others, principally in that part of the section below the Eelwell Limestone. Several of the thin limestones can be observed only at very low water, and only after a careful search, and most previous observers seem not to have understood the section between the Eelwell and the Oxford Limestones elsewhere, with the result that the Oxford Limestone has been supposed to be the Woodend or Hobberlaw Limestone.

There are in all fourteen limestones in this section, varying in thickness from 2 to 35 ft., and amounting altogether to 173 ft. The total thickness given in the section is about 950 ft.: Dryburn to Eelwell Limestones (both inclusive), 400 ft.; Eelwell to Oxford, 500 feet. These thicknesses are greater than those of the corresponding beds at Lowick and Scremerton, and the thicknesses of some of the sandstones here may have been exaggerated, especially as it is not easy to estimate the true dip in undulating and false-bedded rocks.

Beadnell Section.

	Ft. in.
Sandstone, rather fine. [Gap of a few feet, may be shale.]	
1st Limestone, of Ebb's Snook [<i>Dryburn</i>]	30 0
Shales mostly, but with some thin sandstone 10 ft. to	12 0
Sandstone, fine, calcareous at top, with encrinites	}
Sandstone	15 0
COAL -	1 0
Sandstone, shaly and clayey	20 0
Sandstone, coarse and yellow	}
Sandstone, thick-bedded and reddish	50 0
Shales	25 0
2nd Limestone [<i>Lowdean</i>]	35 0
COAL, traces.	
Sandstone, white, and probably shale, with ironstone	45 0
3rd Limestone [<i>Acre</i> or <i>Dun</i>] { Limestone, 2 ft.	}
Shale, 5 ft.	
Limestone, 15 ft.	22 0

* Proc. Ber. Nat. Club., Vol. iv., p. 96.

COAL, thin.			
Sandstone, grey and shaly, with concretions and shales	25	0	
COAL [<i>Acre or Shilbottle Seam</i>] -	1	0	
Sandstone and shale	50	0	
Limestone, dark	6	0	
Sandstones and shales, flaggy	30	0	
4th Limestone [<i>Eelwell</i>] -	25	0	
COAL, thin.			
Sandstone and shale	45	0	
Limestone	5	0	
Shale and sandstone -	about	16	0
COAL [<i>Beadnell Main</i>] -	-	3	0
Shale and sandstone	about	16	0
Sandstone, some rather coarse and thick, with a little shale	100	0	
Shales	20	0	
Limestone -	4	6	
Sandstone, flaggy, and shale	15	0	
Limestone -	3	6	
Sandstone, blocky, and white			
Sandstone and some shale	25	0	
COAL, said to measure	-	1	4
Shales	25	0	
Limestone, may be about	10	0	
COAL, thin, said to be 4 in. to 6 in.	-	0	6
Sandstone, flaggy	15	0	
Limestone	5	0	
Sandstone, massive -	15	0	
[Fault here, some beds may be missing].			
Sandstone, massive; perhaps part of same mass as that south of fault -	10	0	
Sandstone and shale	5	0	
Limestone	2	0	
Stone, clayey, and sandstone	20	0	
Shale, probably	15	0	
Limestone	6	0	
Shale and sandstone	10	0	
Sandstone, brown and white, false-bedded, flattish or rolling	100	0	
Shale -	15	0	
5th Limestone [<i>Oxford or Greenses</i>] -	15	0	
Sandstone and shale	20	0	
Limestone, coralline	4	0	
COAL.			
Sandstone.			

At this point in the section is an important fault running east and west, beyond which is sandstone dipping towards the shore, i.e., south-west.

Besides the coals actually observed in this section there must be several others, some of which have been worked. These will be noticed as we proceed. The dip varies from 10° - 12° in the higher beds and is generally about S.S.E. In the lower beds it is as low as 5° . The highest beds occurring in the section are fine-grained sandstones and below these there may be a few feet of shale immediately overlying :—

No. 1. *The Ebb's Snook or Great Limestone* which forms the Snook or Beadnell Point. This is a whitish or pale yellow magnesian limestone, is very hard, and contains numerous corals as well as *Productus giganteus*, the latter fossil being found in

nearly every limestone of the series. The peninsula south of the harbour has probably been an island, and may be one again some day. The isthmus connecting it with the mainland is flat and composed of blown sand. The beds between this limestone and the next are enumerated in the detailed section. They amount to from 120 to 125 ft. The coal 1 ft. thick has not been worked near Beadnell, but it was worked at Newton-by-the-Sea and at Dryburn near Lowick.

No. 2. This is the *Lowdean Limestone* of Lowick, and is also called the Eight Yard Limestone. It is generally a blue limestone and seems thicker here than usual, but it contains a band of shale a few feet thick. It yielded the following fossils:—

- Zaphrentis ? (fragment).
- Orthis resupinata, *Mart.*
- Productus longispinus, *Sow.*
- „ punctatus var. elegans, *Phil.*
- Spirifera trigonalis, *Mart.*

This limestone rests on a white blocky sandstone (with rootlets) on the shore, and the junction of the two rocks may likewise be observed in the harbour south of Benthall, where the dip is nearly due east. Below the sandstone and lying immediately above the next limestone there is usually a thick shale-band containing many ironstone nodules, but there is a gap in the section where these shales should occur at Nacker Hole.

No. 3. This is the *Acre* or *Six Yard Limestone*, sometimes called the *Dun Quarry*, at Lowick. Its section here is:—

	Ft.
Limestone	2
Shale -	5
Limestone	15

The beds from No. 2 to No. 3 Limestones inclusive are crossed by a whin dyke (see p. 97). The rock is of a bluish colour and is found bounding the Nacker Hole on the north. *Fenestella membranacea?* and an *Orthoceras* were got from it. Immediately below it a coal 6 inches thick is said to occur, and 25 ft. lower comes the Acre or Shilbottle Seam, here only 1 ft. thick, which has been worked at Tuggal Hall, and also south of Newton-by-the-Sea just outside the limit of this Sheet. There are several small veins on the shore to the north of this and one of them has yielded galena in small quantities. The dark limestone 6 ft. thick is a very constant bed, but is seldom seen except in coast or stream' sections. The most important limestone of the series here is—

No. 4. The *Eelwell Limestone*, which has been quarried extensively at Beadnell and North Sunderland, and is locally known as *The Main Limestone*. Its section is as follows:—

	Ft
Irregular sandstone and sandy shale	
Shale with ironstone nodules	5
Calcareous shale with many fossils, brachiopods, &c., and a thin limestone called the cockle-shell post	3
Limestone	22

Numerous fossils were obtained from this limestone on the shore and in the quarries by Mr. Rhodes, the collector to the Survey. The list is too long to give here, and the reader is referred for it to Chapter VI. on the Palaeontology, p. 81. Mr. Tate also gives in his paper a long list of fossils collected by him from this limestone. In the quarries, which are now generally filled with water, the limestone has the same dip as on the shore, viz., about 10° to the south-south-east. The sandstone below this limestone on the shore is traversed in various directions by some curiously hardened joints which form a variety of patterns. The Little Limestone to the north of this, which is 4 to 5 ft. thick, is in two beds, and the surface of it is covered with caudagalli markings. Two coals occur below this—the Eelwell Coals—one of which has been extensively worked inland. Mr. Wilson gives the following section of one of the coal-pits sunk to the Beadnell Coal :—

	Ft. In.
Limestone	27 0
Freestone	39 0
Blue metal	18 0
Limestone	4 0
Blue metal	12 0
Coal	3 0
Grey freestone thill	5 0
Whitish freestone	12 0
Coal	1 5

The exact position of this pit was not ascertained, but the coal is reported to have been 3 ft. thick near the old engine house west of Beadnell Harbour, and it is said to have varied from 2 ft. 6 in. to 6 ft. in different places. The coal was used for domestic purposes as well as for lime-burning. An attempt has again been made of late years to work this seam. The rocks on the shore are traversed by a fault, running south-eastwards and having a small downthrow on the north-east side. It can be traced for some distance across the Main Limestone and the Little Limestone above it nearly as far as the Acre Coal. In the sea bank near Beadnell Square there are traces of two or three thin coal-seams in irregular sandstone and shale, and there is also a portion of a fossil tree standing upright. This may be the remains of the one described by Mr. Tate as follows: "One interesting specimen of *Sigillaria*, which was laid bare when quarrying the sandstone in 1853, deserves a more particular notice. Though but a fragment, it was 6 ft. in height and 2 ft. 2 in. in diameter at the lower end, and 1 ft. 9 in. at the higher; it stood perpendicular to the strata, which dip south-east 15° , and its inclination to the horizon was 75° . The lower extremity terminated abruptly on the surface of slaty sandstone beds, but the outcrop of the rock in which it was imbedded prevented our knowing how far upward it extended. Over the surface was a thin carbonaceous coating being the bark converted into coal, but the interior was converted into sandstone and contained no structure." The part of the section we are now traversing is composed principally of sandstones and shales, the limestones

being but thin and forming only a small proportion of the total thickness. We meet often with indications of shore conditions in the false-bedding of the sandstones and in their ripple-marked surfaces, while the so-called worm tracks afford us traces of the animals which crawled over the sand or burrowed beneath its surface. Mr. Tate, in his paper on the Beadnell Section, figures and describes several varieties of these fossil annelids, but most of these markings are now proved to have been the tracks of crustaceans.

From one of the thin limestones one quarter of a mile north-east of Beadnell, Mr. Rhodes collected the following :—

- Palaeacis cyclostoma, *Phil.*
- Griffithides.
- Chonetes laguessiana, *De Kon.*
- Spirifera.

The coal mentioned as occurring below these two thin limestones is not visible on the shore. The limestone which occurs nearly opposite the old limekiln on the links seemed only about 7 ft. thick, but it is said to be 10 ft. and to have 6 in. of coal below. Both this limestone and the next below it are curiously and sharply bent round to the north, and are cut off there by a fault ranging E.N.E. across the foreshore. Towards low water mark the fault seems to decrease in throw, for the massive sandstones on either side appear to be parts of the same bed, and if so, the fault must have a downthrow to the south.

Only 2 to 3 ft. of the next limestone could be observed, but it may be thicker than given in the section. A boring for coal to the depth of 43 ft. 5 in. was made in 1862 near the limekiln on the links. The details are given in the *Appendix* (p. 134); we only quote here the upper part of the section :—

	Ft.	In.
Limestone	5	0
Coal	0	4
Metal	7	0
Coal	0	7

The remainder consists of alternations of sandstone and shale. It is uncertain which of these thin limestones it is that was found in the boring.

The limestone north of Collith Hole has the following section in one place :—

- Brown weathering blocky limestone with encrinites, 4–5 ft.
- Nodular sandstone and fireclay, 2–3 ft.
- Limestone—a few inches seen.
- Shales, seen at intervals for a width of 30 yds.

This is the bed of limestone given as 6 ft. thick in the general section. The fossil-collector obtained from it :—

- Lonsdaleia.
- Fenestella.
- Orthis Michelini *L'Eveille.*
- Productus giganteus, *Mart.*
- " semireticulatus, *Mart.*

Near high water mark there appears to be a small fault trending nearly due north. The dip of the limestone southward is 7° to 9°,

but the false-bedded sandstone which occupies so much of the foreshore to the northward seems in some places nearly horizontal and in others undulating, so that it is difficult to estimate its thickness. It has been a good deal quarried in places. Passing over a shale band below this sandstone we arrive at—

No. 5 Limestone, the *Oxford* or *Greenses*.—This is found on the shore a little north of the Linkhouse, and it may be traced inland at intervals to near Swinhoe, where it has been largely quarried. It yields corals, crinoid stems and *Productus giganteus*, and dips S.S.E. at angles of 5° to 7° . There is a thickness of about 20 ft. of beds below, principally sandstone of a fine grain, and then we arrive at another coralline limestone with a thin coal below. This limestone is only 4 ft. thick; it overlies sandstone which in a short space rolls over and dips to the north at 20° and a fault is reached which runs east and west. Here the continuity of the section is broken. To the northward stretches for 600 yds. fine massive sandstone parallel to the shore and dipping generally to the south-west at angles of 10° to 15° , the exact horizon of which is uncertain. It is possible it may be the sandstone which overlies the Oxford Limestone to the south, and if so the fault would have a downthrow to the north. However this may be, it is certain that there is a large fault with a downthrow north between the end of this sandstone and the Snook or North Sunderland Point.

There seems also to be a fault bounding the Beadnell section on the south and ranging nearly east-north-east, to the north of the rocks called the Burn Carrs. The rock of the most southerly of these appears to be the Lowdean Limestone resting on sandstone, and that of the most northerly Carr is probably the Acre Limestone; consequently the fault has a downthrow north.

Newton-by-the-Sea.—The Great or Dryburn Limestone appears on the shore at Newton no less than three times. At Newton Point it forms a sloping surface with a dip of 7° to the south-east. It runs out to sea in the headland called Lobster Carr, where it is of a yellowish brown colour and probably magnesian, as it often is. A narrow band of sandstone is seen below at high water mark between the limestone and the Whin Sill to the northward. This band widens out considerably seaward owing to the whin descending in the series along the promontory of Pern Carr, which it forms. Near the base of the whin 150 yds. from the shore a patch of thin-bedded sandstone 6 ft. thick and about 12 ft. long may be observed. Instead of having a gentle dip to the south-east, like all the adjacent rocks, it dips nearly N.E. at an angle of 40° and is truncated at both ends by the intrusive igneous rock. Proceeding northward along the shore we find sandstone in places dipping S.S.E. at angles of 5° to 10° , and soon there is a sharp roll over of the beds, and we find the Whin Sill dipping in a north-westerly direction under the Great Limestone, and with no intervening sandstone; so that here again there is a change in its position. The limestone dips N.W. at 15° , and both it and the whin are crossed by two faults

running N.W., which throw down on the south-west; and 60 yards from the shore both limestone and whin are cut off by a large east and west fault which throws down on the north the sandstone above the Great Limestone. The sandstone lying in a synclinal occupies the greater part of the bay, but is much covered with sand, and the limestone rises from beneath it, with a south-easterly dip of 5° on the north side of the bay. Near the shore at the Snook the lower part of the limestone is white and gritty-looking, and it passes down into 2 or 3 ft. of sandstone which rests on the whin; but further out the whin rises up to the base of the limestone and eventually transgresses that horizon, running out to form Snook Point, and having a fine-grained surface which dips S.E. at 10° . Below this there is a marked appearance of bedding in the rock parallel to the surface and the rock is amygdaloidal. North of the Snook there is a good section on the foreshore, of beds which crop out below the whin, as follows:—

Ft.
Dark sandstone, calcareous at top, with encrinites, 1 ft.
Sandstone, like a coal seat, few inches
Shaly and thin-bedded sandstone, dark and irregular in places
False-bedded and thicker sandstone, some dark and rather coarse
Sandstone roof of coal

Coal, which has been worked—is sometimes as much as 1 ft. 6 in.

Ft.
Sandstone seat and thin clay
Sandstone, mostly thin-bedded
[Gap—may be shale and coal]
Sandstone, fine, with plants, coal seat (?)
Sandstone, mostly fine and whitish, but a band near the middle is coarse and it is thick-bedded and
coarse at bottom

12-15

12-15

50
or more.

The dip varies from 5° to 9° , and in direction from S.S.W. to S.S.E. The calcareous sandstone represents the thin limestone which is generally found below the Dryburn Limestone, and the coal is the Dryburn Coal. The same encrinital calcareous sandstone is found in the Beadnell Section, p. 52, and the coal has been worked a mile west of Newton near the Brunton Burn. Sections of the sandstones and shales are to be seen occasionally in the banks of the burn, and the beds are evidently flexured at gentle angles. Small bosses of whin occur in two or three places, and north of one of these, three-quarters of a mile west of Newton, there seems to be a thin limestone dipping south, to the north of which is found dark shale containing large flattened ironstone nodules, with some crystals of iron pyrites. There would seem to be a large fault on the north side of the burn, trending north-east and with a downthrow north-west; for at Tuggal we find all the four upper limestones striking southward at high angles. The limestone on the north side of Football Hole probably strikes westward, and overlies the whin of Newton North Farm, which has a band 1 ft. 6 in. thick in the middle of a rubbly

nodular, amygdaloidal rock; and the east and west fault of Football Hole is probably prolonged westward by the north side of the village, where the whin and the sandstone below it have both been quarried. Some sandstone is also seen here above the whin, so that the position of the Dryburn Limestone is uncertain. The country inland is drift-covered and obscure, and the limestone cannot be followed. The whin is as much as 20 ft. thick, is clearly transgressive to the sandstone, and a small fault ranging 10° north of west, and throwing down 2 or 3 ft. on the north side, affects both the sandstone and the whin.

Tuggal.—The four upper thick limestones of Beadnell appear in the Tuggal district as narrow bands of rock having a rather high dip to the eastward. The ground is obscure, and there are few outcrops except in and near to Tuggal Burn and Long Nanny. The Great Limestone was only observed to the east of Long Nanny near its mouth, and in an old quarry on the south side of Tuggal Burn. There is a good exposure of the next limestone about Tuggal Mill, and the sandstone below can be seen. The dip is eastward at 20° – 25° . The same limestone has been quarried south of Tuggal Hall, dipping E.S.E. at 25° , and the cellars of the Hall are cut out of the sandstone below, which is probably the rock which has been quarried north of the Hall, where the dip is 20° . The quarry is in a soft false-bedded whitish sandstone with some harder rock, and with red shaly partings. The third limestone is exposed in Long Nanny, where the dip is eastward at 25° , and also in the Tuggal Burn, where the dip is 15° . The Acre Coal was formerly worked west of Tuggal Hall in shallow pits, the traces of which were observed, but the thickness of the seam was not ascertained. South of Tuggal, near the small burn, are traces of old quarries in the Beadnell Main Limestone, and some of the beds above and below it may be observed dipping east at 20° – 25° . The same limestone crops out in Long Nanny about 300 yds. above Tuggal Mill, with an eastward dip of 20° to 30° . The section westward, of the lower beds, is not satisfactory, as rock is seen only at intervals, and the beds appear to be rolling. One bed of limestone may be observed 300 yds. west of the Eelwell Limestone, but it is not possible to identify it.

There are rather high-dipping beds of limestone, sandstone and shale, with thin coal exposed in the railway-cutting a mile south-west of Tuggal Church. These probably lie below the Eelwell Limestone. The dip is 15° – 30° to E.S.E.

Swinhoe and Fleetham.—Two limestones have been quarried at Swinhoe, and another about half a mile to the north-east of the village. The highest of these forms a rather broad band in the fields south of the village, but is apparently not thick, the dip being low, corresponding with the gentle slope of the ground. A coal is said to have been got out below in one of the quarries.

The next limestone crops out in the village, where it is very conspicuous. It rests upon a bed of white sandstone, and the junction of the two rocks crosses the road towards the eastern end of the village, and the sandstone forms a little scar east of

the smithy. All these rocks incline to the south at a gentle angle. The same limestone, faulted, appears in the fields south of Annstead Cottage. There are traces of old coal pits between the two limestones to the south of the centre of the village, and there seem to be others at the north side near the cross-roads, and also 300 yds. north of the crossing. Messrs. Wilson and Tate speak of two coals having been wrought at Swinhoe; the upper one 1 ft. 4 in., and the lower 1 ft. 6 in., the latter of which is identified with that worked at Coally Braes. However this may be, it is certain that these Swinhoe limestones and coals lie above the Oxford Limestone, which has been quarried about one-third of a mile north of the smithy. The Coally Braes Seam above referred to was worked formerly to the south-west of Fleetham, not far from Swinhoe Cottage, and the following represents one of the pit-sections:—

	Ft.	In.
Blue metal	36	0
Limestone	6	0
Coal	0	10
Fireclay and shale	24	0
Coal (worked)	1	6

The dip is 1 in 7, or about 8° , and must be to the E.S.E. Accounts of two borings at Fleetham [see *Appendix*, p. 139], Nos. 1 and 2, would seem to relate to this limestone, and the borings were probably put down to the east of the pits, as they prove higher beds, and one of them (No. 1) has a 6-inch coal, 46 ft. above the limestone. The limestone crops out in the south bank of the stream opposite Fleetham, and a thin coal below it may be observed west of Fleetham Mill. There are numerous exposures of the sandy shale and thin sandstones which are found below the limestone, in the banks of the stream about Fleetham, where the strata have generally a gentle dip to the S.S.E. Below these shales and the coal comes the sandstone, which has been wrought in a quarry now filled with water, 300 yds. north of the stream, at the branching of the road leading from the village. The extremely false-bedded nature of the sandstone is shown in a sketch made by Mr. Wilson in 1852. The true dip as shown by the shale below is at a gentle angle to the S.S.E., while the laminæ of the sandstone dip at an angle of 30° or so, and their ends abut against the bed of shales. This sandstone quarry has recently been reopened (1898) for the purposes of the new railway, and the rock is seen in the cutting close by, overlying a thick mass of shale.

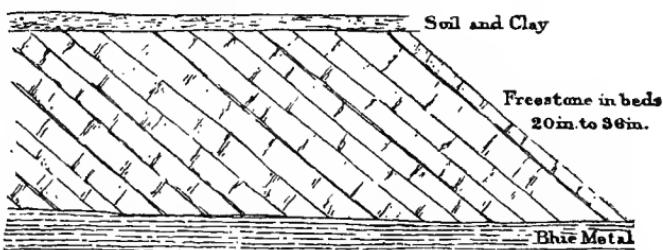


FIG. 4. Sketch of Fleetham Quarry in 1852 by W. Wilson.

The Oxford Limestone was formerly much quarried and burnt for lime to the south and east of Coldrife, but little can now be seen of the rock except in the most easterly of the quarries and in the new railway-cutting. The limestone is said to have been very good, and about 18 ft. thick, in beds of 20 in. to 2 ft., with some shale partings, one of which is as much as 1 ft. The beds undulate gently, but the general dip is to the south at about 10°. There were collected here—*Cyathophyllum* (fragt.), *Syringopora*, *Poteriocrinus* (fragt.), *Productus giganteus*, and *Solemya primæva*. In the Swinhoe Burn, not 400 yds. east of this quarry and on the line of strike occurs a much lower limestone, so that there is probably a fault ranging north-east between the two, which has a downthrow to the south-west. The course of the Oxford Limestone eastward is obscured by drift, but there are traces of it to the south of the Swinhoe Burn, and then it is shifted to the south-east by the fault which passes east of Swinhoe. In the quarry before referred to, half a mile N.E. of the village, the following section of a portion of the limestone was observed :—

	Ft. In.
Limestone, somewhat shaly and impure	4 6
Limestone bed	1 3
Limestone bed	1 6
Limestone bed	4 0

The bottom was not seen. A crush occurs in the quarry with blackened calcite on the side of it, and in another part of the quarry calcite was observed where the bedding was lenticular. The limestone contains many fragments of encrinites and corals, also *Rhabdomeson gracile*, *Orthis resupinata*, and *Productus giganteus* were obtained from it. The dip is south-east at 6°. In the fields to the northward near the Swinhoe Burn there is much sandstone outcropping in the fields, and undulating shale and sandstone may be observed in the burn to the westward, sometimes dipping at high angles. Below these comes a thin whitish coralline limestone, which may be seen in two places in the burn east of the fault, but the best section of it is west of the fault at the part of the burn nearest to Coldrife, where the rock has been quarried. Above the limestone occur thin micaceous sandstone and grey sandstone with plant-remains, and below it, with a general dip to the S.S.E., sandstone of a greenish tint may be noticed in several places. There is not much doubt that this limestone is one that occurs generally about midway between the Oxford and the Woodend Limestones. In the district west of this I have called it the Watchlaw Limestone.

To the south-west of East Fleetham the Woodend Limestone has been quarried a little north of the fault. It is a compact light-coloured limestone, the upper part of which weathers of a brown colour. The rock also crops out in the Engine Burn to the east of East Fleetham. North of this point in the burn, the sandstones which come below the limestone may be noticed, sometimes with a high dip. The Dun Limestone—a blue limestone with a coal below—crops out in several places, to the west of the farmsteading, and it has been quarried in the field

to the north-east of the house. This is the lowest recognisable bed in this neighbourhood. The large fault which brings down the higher beds in the North Sunderland area cannot be far to the north of East Fleetham. There is an old quarry a quarter of a mile west of Burnhouse, and close to the bend in the road there; it seems to have been in a light-coloured grey limestone, which may be the Woodend Limestone curved round near the fault.

Coldrife Colliery, three miles west of Beadnell.—This colliery was abandoned in 1823, and in 1845 Mr. W. Wilson of Shilbottle made a sketch of the workings, for a copy of which, accompanied by notes on the coals, I am indebted to the Rev. Hugh Taylor of Humshaugh-on-Tyne. As will be seen from the Map, two coals have been worked for a distance of nearly three-quarters of a mile along a curved outerop, the seams towards the west end of the workings dipping south and south-east, while on the east side the beds turn rather sharply round and dip to the south-west. The Upper, or Little Seam, was 18 to 20 inches thick—a good clean house coal, very bituminous. Two fathoms of blue metal stone separate this from the Lower, or Big Seam, or Main Coal; an open burning coal with lighter-coloured ash than the upper seam, and good for steam purposes.

The following is the section of the Big Seam :—

	Ft.	In.
Top coal, rather splinty, but good	1	0
Band, black stone	0	2
Bottom coal, good and clean	3	0
	4	2

On the east side of the workings the bottom coal was out altogether and only the top coal left, being a foot thick. This was not owing to the thickening of the band, but to the sudden discontinuance of the lower part of the seam.

The Engine Pit between the two parallel roads was 105 ft. deep to the Big Seam. Another pit near the west end of the workings was about 96 ft. deep, and in this shaft 60 ft. of clay and sand were proved. Both seams were near this soon cut off by the wash, or drifts of clay and sand, not more than a couple of "boards" being to the rise of the water level. The general dip of the beds here is about 7° or 8°. Several borings were made in Mrs. Howey's property, but without success. The coal crops out in this direction, *i.e.*, to the east.

Mr. Wilson thought that the coal lies in a basin. He says the seams are not those worked at North Sunderland, nor does he know that they have been worked anywhere else, nor identified as the same with those of any other locality.

Another account of the colliery makes the engine shaft 99 ft. deep, and the distance between the seams 27 ft.; and this agrees

with the lower part of Mr. Tate's Beadnell Section,* which is taken, he says, from pit-sections. I quote this part below, but do not know whence he obtained it:—

	Ft.	In.
Slaty sandstone	30	0
Blue shale -	6	0
Hardstone [? limestone]	4	0
Sandstone, coarse, white	15	0
Blue shale	12	0
Coal, good	1	8
Slaty sandstones -	27	0
Coal (<i>Main Coal</i>)	4	0
Fireclay	5	0
Blue shale	42	0
Limestone	4	0

The coals correspond exactly with those of Coldrife Colliery, and with the depth and thickness according to the second account given above; and I have no doubt Mr. Tate thought these were the two Scremerston Coals that have been worked at Clattery to the west of Ellingham (and, of course, belonging to the Carbonaceous Division), viz., the Blackhill and Main Coals. This view seems to be quite untenable. The coals have been worked to within 500 yds. of the Oxford Limestone, which has been quarried to the south, where the beds are dipping at a gentle angle of about 10° ; and there would not be room for the 800 ft. of beds intervening between the Oxford Limestone and the Scremerston Coals, unless the dip were as high as 30° or more. Moreover, the section is very unlike that of the Scremerston Coals where known, but is in many respects very like that of the Lickar Coals which come above the Dryburn or Ebb's Snook Limestone. The thickness between the two coals at Coldrife is much less than that between the two Scremerston Coals (41 to 72 ft. in this area), and there is always a limestone, sometimes more than one, a little above the Main Coal, but there is none at Coldrife.

Mr. Burns, farmer, of Glororum, informed me that a Mr. Burn, of Newcastle, sank a trial shaft on the west side of the more westerly of the two roads at Coldrife, and about 300 yds. south of the outcrop of the Big Seam there, of which the following is an oral account:—

Clay, 2 to 3 fathoms.
Limestone, 2 to 3 fathoms.
Thin coal.

The rest was nearly all freestone in a troubled state, and not in beds. They had to blast it. The shaft was 28 to 30 fathoms deep. The coal was never proved, and it seems most probable that we have here but one half of a basin, bounded by a fault on the south side. Now this is just in the line of the Clattery and Annstead Faults, both of which have a large downthrow to the north, so that it seems most likely that the coals worked at Coldrife are the Lickar Seams. The limestone at the bottom of Mr. Tate's section, if ever proved, may be the top of the Dryburn

* *Proc. Berw. Nat. Club*, Vol. iv. p. 96.

Limestone. The surrounding ground is very obscure, and it is probable that there is another large fault on the east side of the colliery, the continuation of one or both of the faults passing by Swinhoe and Fleetham.

North Sunderland and Sea Houses.—The beds exposed along the shore near North Sunderland dip north and south from an anticlinal line ranging east and west through Sea Houses. A very similar section appears on either side the anticlinal line and the beds exposed are the Eelwell Limestone, with its invariable satellites, the thin limestones, that come above and below this limestone. Large faults bringing up much lower beds bound this anticline of North Sunderland on the north and south. The following is a detailed section of the rocks to be observed on the south side near the Snook, the promontory of which is formed of the Eelwell Limestone. The section begins about 100 yds. south of that point and the beds dip due south at about 10° :—

	Ft.
Sandstone and shale	20
Limestone	5
Shale and sandstone	25
Calcareous shale with shells	3
Eelwell limestone	20
Thin coal.	
Flaggy sandstone	
Shale -	30
Dark calcareous shale, with brachiopods	
Limestone, in two beds	1
Shale and thin sandstone	4
Coal—Thickness not observed, but said to be	9
Shale -	4
Thick sandstone, many feet thick.	6

The Eelwell Limestone has been worked inland in a long quarry now filled with water, extending westwards more than half a mile. The Snook coal has been wrought inland for several hundred yards. At the Snook it was said to be 4 ft. 2 in. thick with a 1 in. stone in the middle, but this band thickens to the westward so that at the last pit worked there was more of stone than of coal in the 4 ft. of thickness. In following the shore northwards another coal is observed 250 yds. north of the Snook Limestone. This is a poor seam accompanied by shale, which may be traced for a long distance towards Sea Houses at the foot of the Sea Cliff, the beds being nearly horizontal. About 300 yds. from Sea Houses two small faults ranging north-east may be observed in the cliff. These throw down on the north-west 15 in. and 3 ft. 6 in. respectively. Halfway between this and Sea Houses the sandstone of the foreshore, though really flat, is seen to be partly made up of false-bedded laminæ dipping W.N.W. at 30° . We now pass over the centre of the anticline and find the dip is to the N.N.W. at a low angle, and the thin bed of coal accompanied by shale runs in a curved line out to sea. Opposite the south end of the village a fault running a little east of north may be traced from the cliff across the fore-

shore. It throws down to the east; and a little west from this point in the cliff we find the thin coal and shale again, with a fossil tree-trunk vertical in the shales. The bottom of it is hidden and the top is broken, but the portion visible is 4 ft. long and 1 ft. 3 in. in diameter. The thick bed of sandstone now forms all the foreshore for a long distance, the strike being nearly parallel to the coast-line. We pass over the position of the Snook Coal, which is not seen, and again get a section of all the three limestones with their accompanying sandstones and shales at the Tumblers. The beds are undulating, but the general dip is northward at amounts varying from 10° to 15° . The following is the section of the lowest limestone and associated beds noticed at high-water mark 500 yds. west of the harbour:—

	Ft.	In.
Shelly calcareous shale -	0	6
Limestone, solid	3	0
Shaly limestone	0	2
Shale	1 ft. to 1	6
Coal	0	10
Fireclay	2	0
Shales.		

The following fossils were obtained here* :—

- Alveolites depressa, *Flem.*
- Lithostrotion junceum, *Flem.*
- Poteriocrinus (stems).
- Productus longispinus, *Sow.*
- Spirifera trigonalis, *Mart.*

The two corals were also found in the thick limestone to the northward, and in addition were found:—

- Syringopora.
- Poteriocrinus crassus, *Mill.* (fragment of stem).
- Productus giganteus, *Mart.*
- Actinoceras.

A long list of fossils obtained from this same limestone at the Snook and in the quarries, will be found in the chapter on Palaeontology, p. 81.

This limestone near the Tumblers, opposite Shoreston Hall, affords most interesting examples of local erosion in Carboniferous times. The upper surface of the limestone after its deposition was subjected to denudation before the sandstone that overlies it was deposited. The usual order of succession in these rocks is:—

- Shale.
- Limestone.
- Sandstone.

It is an almost invariable rule that shale overlies limestone, so that it is possible in this case that the shale which originally

* Mr. Rhodes in a note says " *Productus giganteus* is pretty abundant in a bed laid bare some time in the winter of 1882-83, a quarter of a mile N.W. of Sea Houses. Two or three species of corals are also fairly abundant, *Lithostrotion* the most conspicuous."

covered the limestone has been carried away also. Figure 5 represents some of the phenomena observed.

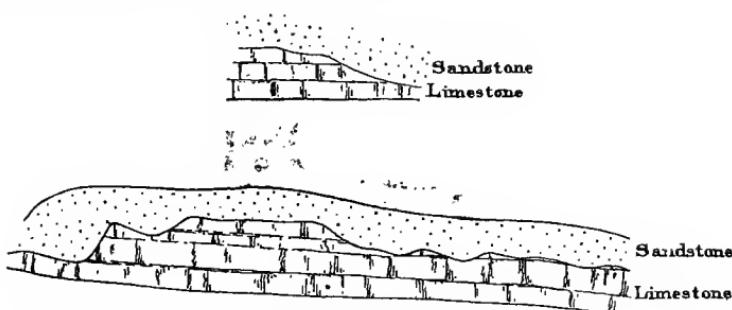


FIG. 5. Examples of local erosion of limestone near Sea Houses opposite Shoreston Hall.

These sketches were taken about 200 yds. from the shore, and not far from the large fault which crosses the foreshore here in an east and west direction. This fault seems a complicated one: there are certainly two branches of it, and there may possibly be more, and the principal throw which brings up the beds below the Oxford Limestone may be somewhat farther north. A bed of limestone dipping eastward may be observed between the two faults visible, and there are small outcrops of limestone to the north of this, but they are too fragmentary for recognition. The coal workings at Shoreston Hall were, it is said, cut off by a "trouble," and a boring which was made on the links opposite the end of the road leading from Shoreston Hall, is said to have been 40 to 50 fathoms in depth, without finding coal. A trouble (or fault) is reported to have been met with however.

The Snook Coal Seam appears not to have been worked on the north side of the anticline. The coal worked south of Shoreston Hall seems on a much lower horizon, and more nearly to correspond to the thin coal noticed in the cliff east of Sea Houses.

The following was given as a section of one of the pits:—

	Ft. In.
Soil and clay	2 1
Limestone	4 0
Coal	0 8
Freestone	66 0
Bituminous shale	25 4
Coal, with 12-inch band of shale	4 6
	102 7

Mr. R. G. Bolam of Berwick supplied me with a detailed section of the coal:—

	Ft. In.
Top coal -	1 9
Seggar	1 2
Coal	0 7
Seggar	0 5
Coal	1 1½
Splint coal	0 5
	5 5½

The beds here dip to the north-east, but they curve round and dip south-east between Sea Houses and North Sunderland, where this North Seam, as it is called, has been proved in a shaft of 11 fathoms. The coal, however, on this side is unworkable. A well near the east end of the village was sunk 12 ft. to the seam, and it was found to be a poor coal 2 ft. in thickness.

Two thin limestones, separated by a few feet of sandstone and shale, crop out in the village, below the North Seam. The highest of these is traceable for some distance, and the lowest, which can be seen near the United Presbyterian Chapel, at the west end, is said to have a coal below. These two limestones correspond with two at Beadnell which are the second and third counting from the Eelwell, Limestone.

A coal called the Silver Seam has been worked a little on the north side of the village. Little could be learnt about it, but it must be below these two limestones, and may be the same coal which has been worked in shallow pits 200 to 300 yds. south of Westfield, and which may outcrop to the south.

The Eelwell Limestone may be observed in quarries near Southfield and Pasture Hill, and the Eelwell Coal, or Snook Top Seam, as it is here called, has been worked continuously for nearly two miles to the north of these farms. The seam was 1 ft. 6 in. thick, and good coal with a metal roof.

At the farm of Pasture Hill 27½ ft. of sandstone were proved in a well. There are traces of coal-pits a quarter of a mile south of the house, where the Acre Seam may have been worked. To the west of this another coal has been extensively worked for a distance of more than half a mile. According to one account this was a poor seam 18 in. thick, and the same as that worked from the Engine Inn, viz., the Snook Top Seam. Another account gave it as a slaty seam 2 ft. thick, with a limestone roof, and the same as the Beadnell Coal. It appears clear that the seam is in a faulted area, whatever is its position. A limestone has been quarried at Cracker Pool to the northward, which has a thick mass of shale above it, exposed in a cutting to the east of the quarry; but the position of this limestone in the series was not ascertained. It dips to the south-east at a low angle. A whitish micaceous false-bedded sandstone with a similar dip is to be seen at the village of Elford, and about 600 yds. to the north of this a blue limestone, also dipping south-east, has been extensively quarried. It is encrinital and coralline, and reminds one of the Oxford Limestone. The beds are undulating, but the average dip S.E. is from 5° to 8°. The section is:—

	Ft. In.
Shale, rather sandy, with small ironstone nodules in lower part	8 0
Limestone	3 9
Limestone, generally in two beds	3 6
Shale parting	0 3
Limestone	3 ft. 6 in. to 4 0
Shale parting	0 2
Limestone, rather shaly	2 6

Below there is said to be a 6 in. to 9 in. seam of coal.

The following fossils were got here:—

- Zaphrentis ?.
- Crinoid stems.
- Fenestella (fragment).
- Rhabdomeson rhombiferum, *Phil.*
- Orthis.
- Productus giganteus, *Mart.*
- Spirifera trigonalis, *Mart.*
- Streptorhynchus crenistrial, *Phil.* (fragment).
- Bellerophon (fragment).
- Microdoma quadrisserrata, *de Kon.*
- Porcellia.
- Cyrtoceras rugosum, *Flem.*

Two other beds of limestone crop out between the Elford quarry and New Shoreston. These both dip to the southward, and the lower one apparently overlies the thick white micaceous sandstone that has been quarried near the road to the southwest of New Shoreston. It seems most probable that these beds are above the Oxford Limestone, and that they are separated from the Elford quarry by a fault; but much of this area is very obscure, and the ground to the west as far as the railway, is so thickly covered with glacial drift that nothing is known of the solid geology.

Bamburgh.—We will describe under the Bamburgh district the area lying north of the large fault through Shoreston Hall. Probably the lowest bed outercropping in this area is a bed of white fine-grained limestone which may be seen in the fields on either side of the road about 200 yds. north-west of Shoreston Hall. It dips to the N.W. at a low angle, and is probably the bed described as the Watchlaw Limestone in the burn east of Coldrife. On the shore the Oxford Limestone is twice seen, at Monkshouse and at Greenhill Rocks, and south of Monkshouse a series of sandstones and shales with two thin limestones, all dipping north, at angles of about 10° , lie below the Oxford Limestone. The lowest beds visible opposite the Shoreston Outcarrs consist of grey micaceous sandstone, occasionally of a greenish tinge, above which comes white sandstone with nodules. This is occasionally calcareous and lies next to the lowest thin limestone. This last is somewhat irregular and lumpy, from 1 to 2 ft. thick, with many corals and *Producti*. It is very fine-grained and weathers with a brown-red tint. Above this come several thin alternations of shales and fine sandstone, about 50 ft. thick altogether, and then comes another thin limestone. The beds between this and the Oxford Limestone are about 50 ft. thick, and are made up of sandstones, and of shales with ironstone nodules. Just below the Oxford Limestone is a thin coal, and there are traces of coal in other parts of the section. The Greenses coal should come between the two thin limestones described. The limestone of the Monkshouse Rocks is undulating, but still the dip is northward, and between this and the Greenhill Rocks the foreshore is formed of the shale overlying the Oxford Limestone, in some places nearly flat or gently undulating. A fault running east-west 250 yds. north of Monkshouse with an upthrow north of about 100 ft. repeats the Oxford

Limestone and the first Little Limestone below. Near the fault in places the rocks are thrown nearly on edge, and dip south about 60°, but the general dip, north of the fault, is to the north-east, at a comparatively low angle.

This fault has the greatest throw near the shore, and towards low-water mark it is considerably less than 100 ft. The shale above the Oxford Limestone can be seen near the fault, but further north the limestone undulates and covers a larger surface. At its northern end where it strikes the shore-line it is crushed and contorted, and there is much slickened calcite on the bedding-planes. Below the limestone is a trace of coal with a stony underclay. The limestone contains many fragments of encrinites, and both here and at Monkshouse fossils were obtained which will be found tabulated, *see p. 88.*

At Redbars is a deep sandstone quarry, the beds of which dip south. The rock is nearly all rather fine and white, and there is much fine light-brown clay in the joints of the stone. The section of this quarry is as follows:—

	Ft. In.
False-bedded sandstone, rather rubbly	11 0
Thick white sandstone	5 to 6 0
Thin micaceous sandstone with coaly partings	0 2-3
Thick white sandstone, seen to	8 0

It is said there are several feet of the best sandstone below this. At the top of the north end of the quarry the stone is much broken up.

A thin limestone with a northerly dip crops out at Greenhill. There were two sinkings and borings made here in which some thin coal seams were met with. Depths of 41 ft. and 60 ft respectively were proved in these.

To the west of Greenhill is an anticline, for when we see the Oxford Limestone again it is dipping south-west at a low angle, 5° or even less. The thickness of the limestone could not be ascertained, but the following section occurs below it in the Ingram Burn: the beds all dip westward, or to the W.S.W.:—

	Ft. In.
Limestone.	
COAL	0 6
Sandy or clayey shale and thin rubbly sandstone with plants	4 0
Shale	3 0
[Gap]	
Shaly sandstone.	
COAL	0 8
Shale	
Limestone	4 0
Shale and probably Coal.	

These beds seem cut off on the south by the Monkshouse Fault. On the west side of the Ingram Lane a limestone has been quarried which is probably a continuation of this. It seems nearly horizontal. To the south of this, and west of Fowberry, a good coal 14 in. thick was worked in pits 16 ft. deep. The seam dips to the south-east.

The quarries at Burton are probably in the Oxford Limestone again. The rock dips eastward at a low angle in the quarries, but south of the farm the dip is to the south. The limestone is said to be 15 to 18 ft. in thickness. There was noticed in the quarries :—

	Ft. In.
Limestone in 2 or in 3 beds, largely composed of encrinites with some corals	8 0
Shale	0 4·5
Limestone, more compact, seen to	6 0

There is a coal 6 in. to 8 in. thick below the limestone. There were collected here *Alveolites septosa*, *Productus giganteus*, *P. semireticulatus*, and *Terebratula*. Sandstone, which must underlie the limestone, crops out near the farm-steading, and to the westward a coal has been wrought extensively in shallow pits. It apparently lies below a thin limestone and must have been worked for lime-burning. It may be the Greensense Coal.

To the west of this, and south of Glororum, two other coals have been worked, said to be respectively 1 ft. 5 in. and 2 ft. 4 in. thick, which dipped south-east at about 1 in 20, or nearly 3°. Judging by the crops there would seem to be a regular succession westward from the Burton Limestone down to the lowest of these coals, and there must be a fault to the north between these rocks and the Glororum Limestone, which dips to the south at a low angle. This limestone may be the Oxford, but is more likely to be a higher limestone. It has four inches of coal below, and yielded to the fossil collector :—

- Rhabdomeson gracile ?, *Phil.*
- Chonetes laguessiana, *de Kon.*
- Productus (fragment).
- Streptorhynchus crenistria, *Phil.*
- Posidonomya Becheri, *Goldf.*

The whole of this country round Bamburgh is much obscured by glacial drift, and the rocks as far as can be observed are flexured a good deal as well as faulted, so that not much of the structure can be made out. It seems probable, however, that we are in the main dealing with the beds that are associated with the Oxford Limestone, and with those that come between it and the Eelwell Limestone. In fact, with the exception of the Burton Limestone, which may possibly be the Eelwell, nearly all the other limestone outcrops where quarries occur are probably to be referred to the Oxford. There is a broad band of limestone crossing the road to the south-west of Bamburgh which is undulating or nearly horizontal. The village itself is on sandstone, which is met with in the churchyard at a depth of 4 ft. to 9 ft., and which is close to the surface south of the road. The Grove, in the centre of the village, is the site of an old sandstone quarry from which the rock was obtained for rebuilding the Castle; and sandstone with some shale underlies the whin along the south-west side of the Castle itself, and was proved to a depth of 75 ft. below the whin in the Castle well. Commencing about 70 yds. west of the entrance lodge, sandstone may be at intervals observed

below the Castle rock for a length of 230 yds., after which, owing to the gentle north-easterly dip, it is covered up by the blown sand which almost entirely surrounds the Castle. In one place near the north end of the section, part of the sandstone with a high dip is nearly inclosed in the intrusive basalt.

No rock appears on the shore for about a quarter of a mile north of the Castle, when at or near low-water mark we see patches of sandstone and shale, not altered, dipping gently eastwards. At high-water mark 550 yds. from the Castle we first come to the whin, the edge of which appears to run in a north-easterly direction. Following this line we shortly see an inclusion of fine grey sandstone in it. The patch of sandstone is 11 yds. in length and the rock dips N.N.E. at a high angle. Many other patches occur farther north, and near low-water mark a mass of baked shale 150 yds. in length is met with in addition to numerous small patches of the same rock. In the larger mass of shale a dyke-like portion of whin 16 yds. in length occurs. Nothing but a plan on a large scale could give any idea of the shape, size, and number of these inclusions. Two sketches are given to show some of them. The first of these (Fig. 6), which is near the

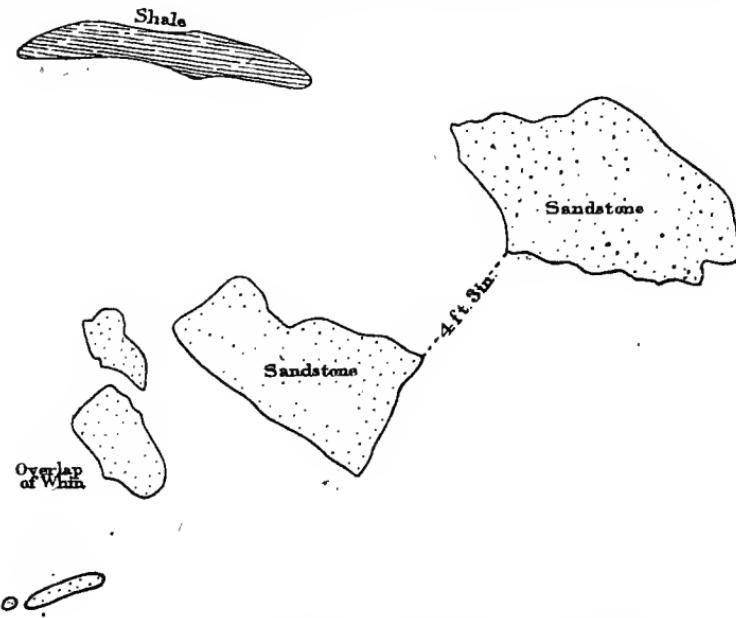


FIG. 6.—Plan of inclusions in Whin, Harkess Rocks.

southern edge of the mass, is drawn to a scale of about 1 in. to 6 ft. The surface of the basalt slopes gently eastward, and besides the inclusions there are fragments of baked shale sticking to its surface here and there. The rocks are crossed by two sets of veins or faults, one of which ranges W. 15° N., and the other and more numerous set has a direction nearly E.N.E. Some of the latter are very conspicuous west of the target, or between it and the Stag Rock, and opposite the mineral well. Some of these veins contain barytes and iron-pyrites. The second sketch-plan

(Fig. 7) represents a portion of these. The sandstone between the two veins is fine, white, and ripple-marked, and dips W. 30° S. at 10° . Further eastward we find rather coarse sandstone dipping E. 10° S., apparently at an angle of 60° . This mass is bounded by whin on every side, except on the north, where the

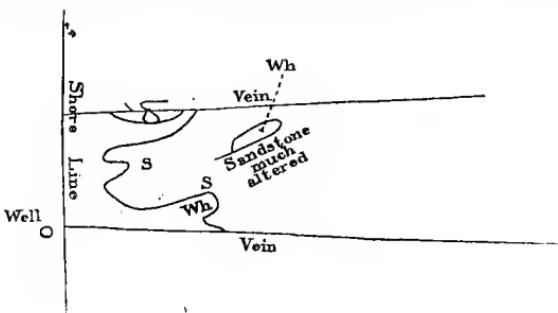


FIG. 7.—Harkess Rocks. Sketch plan west of Target. Scale—1 in. to about 27 yards.

vein occurs. Bordering this vein for some distance on the north side is a narrow band of dark-coloured limestone dipping N.N.W. at 25° – 30° . Beyond this for a distance of 30 yds. is a level surface in which sandstone crops out, and this is bounded on the north by the curved cliff known as the Stag Rock, from the figure of a stag which it bears. The rocks here all dip to the north-west at angles of 10° – 15° near the shore, curving round so as to dip east of north near low-water mark. The section of the Stag Rock affords perhaps the most striking instance of intrusion of the igneous rock to be seen at the Harkess Rocks, which is the general name for the rocks of this part of the Bamburgh Coast. Near high-water mark the following is the section:—

	Ft. In.
Whin.	
Shale	2 3
Limestone	4 6
Shaly and sandy limestone, a thin band.	
Sandstone.	

The shale can be followed for 25 yds. till it disappears, and the basalt comes on to the limestone, which again in turn disappears a few yards further, and the whin then rests on the sandstone at the foot of the cliff. For a distance of 40 yds. this continues, when the limestone reappears, and 12 yds. further the shale, above-mentioned, emerges, and for 10 yds. we are presented with a section almost exactly like that with which we started. The shale here is of a reddish colour, indurated, and is 2 ft. 6 in. thick. The limestone below is 4 ft. in thickness. Below it is fine sandstone, soft and argillaceous, 5 to 6 ft. thick, and still lower coarse mottled sandstone with some shale, perhaps 20 ft. in thickness. At the back of the Stag Rock, on the surface of the whin, sloping northward, are three isolated patches of blue altered limestone. The largest of these is 25 yds. long and 2 ft. 6 in. thick; the others are but 12 to 15 yds. in length. Small cakes of lime-

stone adhering to the basalt may be observed north of these. These limestone patches probably all belong to the bed which appears in the Stag Rock. The principal patches on the whin occur opposite the place in the rock where no limestone is found below the whin. Fragments of *Poteriocrinus* stems were collected here, also a turbinate coral, indeterminate.

To the west of the Stag Rock and just north of the promontory formed by the whin, limestone appears to come up from beneath the whin in an anticline, so that the sheet of intrusive rock is not very thick. In the little bay to the west of the promontory limestone is again visible, dipping to the north, with shale overlying it in one place. This patch of limestone is very irregular in shape. It is a narrow band, running east and west, from which two arms project southward. To the north of this are some very small patches of altered rock adhering to the basalt, and these contain sparry nests 3 to 4 inches long, which are filled with quartz. The whin itself is often vesicular, the cavities being filled with calcite. About 200 yds. W.N.W. of the Ordnance Station we find embedded in the whin a curious semicircular band of limestone. The convex of this curve faces the south--its chord has a length of some 25 yds., and the dip on the west side is to the N.E. at 30° ; on the east side it dips N.W. at 20° . To the west of this it is evident that as we proceed we are walking on the original surface of the sheet, for the "scares" of limestone are very numerous, and soon we arrive at a synclinal ranging north and south.

About 400 yds. west of the Ordnance Station the whin comes to an end rather sharply along a line running north-west, which seems partly a faulted one. Westward from this we find a considerable stretch of limestone on the foreshore for a distance of 200 yds. Near the centre of the patch an irregular-shaped mass of whin running in a N.W. direction protrudes, and near the west side another irregular-shaped mass of whin occurs which sends out a dyke-like spur to the north, 1 ft. to 3 ft. wide. The limestone is probably the same bed as that we see at the Harkess Rocks (Stag Rock) and in the small patches occurring here and there in the intervening area. It seems to be but a thin bed—one of those which occur between the Oxford and Eelwell Limestones. At the place last described it is nearly horizontal, with only a very gentle northerly dip.

On the west side of the bay, beyond Freshwater Cairn, several small patches of sandstone occur in the whin. These are horizontal. At 150 and 200 yds. west of this bay we observe similar patches of sandstone which dip to the south-east. The whin about here, as also east of the large limestone patch, has a bedded appearance, and this phenomenon is not at all uncommon, especially near one of its surfaces. An interesting section occurs 200 yds. east of Budle Point, where most of the patches included in the whin consist of sandstone; but there are two of limestone—one small patch at high-water mark is dipping north, and there is another, 7 yds. long, 30 yds. from the shore. To the

south-east of the latter a sandstone patch 2 ft. in thickness can be traced below whin for 30 yds., except for a distance of $4\frac{1}{2}$ ft., where the whin comes down and cuts it out. This strip dips to W.S.W. About 40 yards nearer Budle Point, dark-coloured limestone occurs close to the shore. At Budle Point a cake of altered sandy shale lies on the pseudo-bedded whin with a northerly dip of about 15° . The surface of the whin here is very amygdaloidal, and this character extends downwards to a depth of 5 or 6 inches, the cavities being filled with calcite. Fine examples occur about here of the polishing and grooving action of blown sand upon the whin, the furrows running east and west, i.e., parallel to the coast-line we have been describing.

Between Budle Point and Heatherhouse three patches of limestone are found, but one, of these is very small and near the shore. The dip seems now to be generally to the north-west, and the strike is parallel to the coast-line, as it is in the main between Budle Point and the Harkess Rocks, where the coast bends roughly east and west. At Heatherhouse the whin is again markedly amygdaloidal. Three hundred yards west of the house we come upon an exposure of limestone which stretches along the foreshore for more than 200 yds. The bed strikes with the coast and has a gentle dip seawards, and above it in the scabank about 4 ft. of reddish shale may be observed. Both the limestone and the shale contain an interesting suite of fossils. The limestone has been quarried and burnt to the west of this, where a road comes down to the shore from Budle; and farther south and due westward of Budle, the limestone crops out again on the shore, and above it is a fine section in fossiliferous shale and sandstone amounting to nearly 30 ft. as follows:—

Shaly sandstone.	Ft.
Soft greenish-grey micaceous sandstone	15
Shales, fossiliferous below	12 to 15
Limestone.	

In one place a small intrusion of whin occurs in the shale. From these beds numerous fossils have been obtained by the late G. Tate, of Alnwick, and by the Survey Collector. It is the principal locality for fossil plants within this area, and almost the only one that has yielded fossil ferns. Mr. Tate says, "we have found them (ferns) only in one locality at Budle, in a red argillaceous shale, associated with other plants and marine shells, among which is *Posidonia tuberculata*. This interesting deposit, which is about 30 ft. thick, contains in the lower part many marine remains, but as we ascend upward, a fragment of a land plant, which had been floated into this ancient estuary, here and there appears; and in the uppermost part, the marine fossils are almost entirely gone, while considerable numbers of land plants are spread out between the layers of shale."* Mr. Kidston has revised the names given by Mr. Tate, and the list will be found in the *Appendix*, p. 132. The list of fossils

* Johnstone's *Natural History of the Eastern Border*, p. 306.

collected by the Survey both here and at Heatherhouse is given below:—

Fossils from shore section W. of Budle. Chesterhill Slakes.

- Sphenopteris Dicksonoides, Göpp, sp.
- " sp. (*Bgt.*) Stur. (allied to *S. elegans*).
- " sp.
- Rhodea moravica, Ett.
- Stigmaria ficoides, Brong.
- Caulopteris.
- Plant impressions.
- Dithyrocaris tenuistriata ? McCoy.
- Posidonomya Becheri, Goldf.
- Ctenodonta.
- Schizodus.
- Bellerophon decussata, Flem.
- " Urei, Flem.

Fossils from shore section near Heather House, Budle Bay.

- Alveolites septosa, Flem.
- Chonetes laguessiana, DeKon.
- Lingula mytiloides, Sow.
- " squamiformis, Phil.
- Productus scabriculus, Mart.
- " semireticulatus, Mart.
- Streptorhynchus crenistria, Phil.
- Posidonomya Becheri, Goldf.
- Schizodus ?
- Bellerophon (fragment).

The most interesting fossil in this list is *Posidonomya Becheri*. This shell has hitherto not been found in North Northumberland, below the Oxford Limestone, i.e., the base of the Yoredale Series, and it is said to characterise the Upper Limestone Series or Calp of Ireland. Its presence on the coast of North Northumberland is referred to by Sir R. I. Murchison.*

The limestones worked at Spindlestone and at the Hoppen quarry, near Goldenhill, must be referred to the Oxford. The Hoppen lime seems a very pure one, an analysis showing it to contain only 0·56 per cent. of silica. The dip is westerly, and the following is the general section of the beds according to Mr. Harvey, the manager.

	Ft. In.
Tills (shale)	4 0
Top post	20 in. to 2 0
Post	3 ft. to 3 6
Metal parting	4 in. to 0 8
Thin beds	18 in. to 1 8
Middle post	4 ft. to 4 6
Bottom post	9 in. to 2 6
Calcareous shale, about	1 0
Coal	0 6

Details of a boring here will be found in the *Appendix*, p. 140. Westerly dips prevail all down the stream from Bradford to Spindlestone, mostly in sandstones and shales; but limestones occur at Bradford, and south of Spindlestone House, as also in

* *Siluria*, 4th ed., 1867, p. 291.

the fields between Hoppen quarry and Lucker Station. At Spindlestone quarry the dip is northward at a low angle, and the limestone seems to cover a considerable area. From 8 to 12 ft. of limestone has been worked here, and there is said to be a good coal 8 in. to 12 in. thick below it. Near the bottom of the lowest bed in this quarry there are said to occur hard round balls varying in size from that of a hen's egg to that of a man's head. They are also found in the till bed below the limestone, and are said to occur in the Monkhouse Limestone, and in the Hoppen quarry. From the latter quarry were obtained: *Alveolites*, *Encrinite* stem, *Productus giganteus*, *Spirifera trigonalis*, *Solemya primæva*; and from a sandstone quarry three quarters of a mile S.W. of Glororum Farm House a specimen of *Lepidodendron volkmannianum*.

The Farne Islands.—Stratified rocks may be observed at four places among the Farnes. Two of these are on the Brownsman, one on Roddam and Green, and the other and largest exposure is at the Bridges, east of the Farne or Inner Island, between Wideopen and the Knoxes, but it can only be examined at low tide.

The strata exposed at the Bridges form the western part of a synclinal, and the uppermost beds noticed consist of red calcareous shale and red limestone, with Trilobites, *Productus*, and *Spirifera*. The lower part of the limestone is not reddened, but is of the usual blue grey colour. It is altogether 15 to 20 ft. thick, and is probably more. The basalt comes close up to the limestone on the north side, near Knox's reef, except in one place where 3 to 4 ft. of fine sandstone intervenes, and the dip is S.S.E. at angles of 10°–20°. On the west side towards the Kettle there is a width of 40 or 50 yds. below the limestone where nothing can be observed, and then appears a hard compact limestone 4 ft. thick, which can be traced southward for 30 yds., and below this, with a dip to the E.N.E. of about 7°, sandstone appears for a breadth of 17 yds. This whole section at the Bridges probably represents the Eelwell Limestone and the beds below.

There were collected here:—

Phillipsia Eichwaldi (var *mucronata*), *Fisch.*

Fenestella membranacea, *Phil.*

Productus fimbriatus, *Sow.*

„ *longispinus*, *Sow.*

„ *semireticulatus*, *Mart.*

Spirifera trigonalis, *Mart.*

(The *Phillipsia* is Mr. Tate's "*Griphithides Farnensis*.")

The next largest exposure of stratified rock occurs west of the old lighthouse on the Brownsman Island (called by Mr. Tate "Fosseland." It is an oval patch of about 70 yds. by 50 yds. occurring on a ledge which is generally accessible, but is covered by the highest tides. It is everywhere bounded by the basalt, which forms a scar below it on the west side, and seems to rise through the stratified rock near the centre, while another scar of whin rises above it all round the north and east sides. The section is not a satisfactory one, being only fragmentary, and I could make

out nothing approaching to the 90 ft. of thickness described by Mr. Tate. The whole of the rocks, too, are much altered by the action of the basalt. However, there seems to be a general easterly dip, and the lowest rock noticed on the west side is hardened sandstone resting on the whin, and apparently 3 ft. to 4 ft. thick. It dips gently to the north-east. On the east side towards the south end fine hard flinty calcareous shale appears. This has a low dip to the E.N.E., and may be 2 ft. to 3 ft. in thickness. Northward from this sandstone appears with a similar low dip for a breadth of a few yards, and may be 3 ft. or 4 ft. in thickness. At the north end is a small section which gives the following somewhat doubtful succession :—

Limestone.
Sandstone.
Shale, altered.

Blocks of blue limestone lie scattered about, but very little could be seen in place. Mr. Rhodes, the fossil-collector, obtained here :—

Phillipsia Eichwaldi (var mucronata), *Fisch.*
Fenestella sp.
Pecten Sowerbyi (bad).
Orthoceras (fragments).

Mr. Tate, in his paper on the Farne Islands, gives a long list of fossils collected by him, most of which are from Fosseland, but only six species from these islands were found in the Alnwick Museum by Mr. Etheridge (*see Appendix*, p. 128).

To the east of the Brownsman tower and a little above high-water mark may be observed another exposure of stratified rocks in a small pool. A foot or more of limestone may be seen resting on 3 to 4 ft. of sandstone, and the narrow band of altered rock may be traced for 30 yds. in length. The dip is at an angle of 25° to 30° in a direction W. 30° S., or almost exactly opposite to that on the west side of the island, so that between the two outcrops there is a synclinal which probably ranges in a north-west direction past the North Wamses, where we find the whin surface dipping to the south-west.

The other patch of non-igneous rock occurs on the small island called Roddam and Green, which lies to the east of South Wamses. The patch is almost due north from the house on the Brownsman and occurs a little below high-water mark. It is from 4 to 5 yds. long and consists of a much altered quartzose sandstone. The basalt is seen nearly all round it.

It is possible also that there is a strip of Carboniferous rock in the gut or hollow between Brownsman Island and Staples Island, which is laid bare at low-tides; but if so it is hidden by the shingle which fills the hollow.

The limestone on the Brownsman may be the same as that described before as occurring at the Bridges, but it is more probably a higher limestone, and not unlikely the Lowdean.

Holy Island.—This is the largest of the islands on the coast of Northumberland, having an area of about 1,050 acres. It is irregular in shape; its main part is a rude square rather over a

mile in the side, which sends out westward a tadpole-shaped arm $1\frac{1}{2}$ miles in length, the end of which, Snook Point, is only $\frac{3}{4}$ mile from the Beal Shore. The island is generally approached from Beal by a track across the sands $2\frac{3}{4}$ miles long, which is passable for vehicles or foot-passengers at half-tide. In *Marmion*, Canto II., Sir W. Scott, says—

“Dryshod, o'er sands, twice every day,
The pilgrims to the shrine find way.”

The island is interesting for its historical associations. The Castle, and the ruins of the Priory are conspicuous objects from the railway south of Beal.

The greater part of the area of the island is covered by superficial deposits—blown sand, boulder clay, alluvium and raised beaches—so that solid rock appears only near the coast, more particularly on the north, east, and south sides of the main portion. On the long arm, rock can be observed only on its north side close to the shore, about half a mile from the Snook Point. There is only a small section in limestone to be seen, but limestone is said to have been quarried here at one time, and there is a limekiln among the sand hills 100 yds. to the south of this place, besides traces of several old coal-pits which furnished the coal for lime-burning. The coal is said to have been thicker and softer than the one next described, and had ‘dent’ for a roof, so that it was probably as much as 18 in. to 2 ft. in thickness. The limestone worked here is most likely the Eelwell, and the coal worked is one of the coals that lies below that limestone. In the *Appendix* (p. 138), will be found an account of a boring for coal made in the year 1792, somewhere on Holy Island, probably on the Snook. The blue stone of the boring is probably limestone; ‘whin’ may be any hard rock. I think the coal and limestone of the boring are those described above.

Another old coal pit occurs a mile to the eastward, at the Shiel, where the Snook joins on to the main part of the island. This I was informed was 12 or 13 fathoms deep, and was sunk through the following beds—

Sand and Gravel	—
Limestone	$12\text{-}14$ ft
Coal	6-8 in.
Freestone, blackveined	—
Coal	$1\text{-}1\frac{1}{2}$ ft.
Fireclay	—

It seems pretty clear that the limestone sunk through is the Acre, and the coal worked the Acre Coal. The limestone is visible not far off to the north and along the foreshore to beyond the Snipe Point, where it runs out to sea and where it was formerly quarried. There are many undulations of the limestone along the shore, many of them very sharp, but the general dip of the rock is to the south-east. About 40 yds. north of Snipe Point the bottom of the limestone is exposed, and there is a trace of a thin coal and underclay. The rocks which underlie these are soft shaly sandstones or sandy shales, light grey in

colour, containing many hard grey nodular lumps of concretionary sandstone with calspar; and below these the beds are principally sandstones. A crush running W.N.W. crosses the limestone east of Snipe Point, and this may also be observed in the next limestone further eastward. From the Acre Limestone here were obtained *Alveolites*, *Zaphrentis*, *Poteriocrinus*, *Archæocidaris* spines, and *Euomphalus*.

The beds above the Acre Limestone are shales with large iron-stone nodules, but only the upper portion can be observed in Caves Haven. Above these are thin-bedded sandstones, and overlying these occurs a thick-bedded white sandstone, which has been much hollowed out into caves (weems) by the action of the sea. The dip is south-east at 5°. This sandstone is capped by the Low Dean Limestone which has been here largely quarried for exportation and which runs out to sea from the headland called Nessend to the Castlehead Rocks, forming a prominent skerr.

This limestone cannot be traced inland for more than about 350 yds., when it becomes hidden by the blown sand. There are some quarries in the subjacent sandstone just north of the links. The limestone, however, has been proved by boring on the south side of the links at the north end of the road which leads from the village. It was 9 ft. below the surface and covered by clay. A boring about 100 yds. farther south on the east side of the road was entirely in sand. A large specimen, nearly 6 ft. long, of *Actinoceras giganteum*, obtained from the quarry at Caves Haven is now in the Jermyn Street Museum. For fossils collected here reference must be made to the Chapter on Palaeontology (see p. 83). Only the lower part of the shale which overlies the limestone is visible in the quarry and on the coast south of Nessend. The limestone which forms Keel Head is of a yellowish-brown colour. Its thickness could not be ascertained, and whether it is the Low Dean Limestone brought up by a fault, or the Dryburn Limestone faulted down, is uncertain. No limestone in a natural position so near to the top of the Low Dean Limestone is known.

The Low Dean Limestone may be observed on the south side of the island on the foreshore opposite the ruins of the Cathedral. It has here an eastward dip, and is much altered by the action of the basalt dyke which forms The Heugh to the northward. The calcareous shale overlying the limestone is much indurated. Wells at the Vicarage and at the Coastguard Station have been sunk in the sandstone underlying the limestone, and this is said to be near the surface in the field south-east of the Ship Inn. In the low cliffs west of the village there crops out the shale with large ironstone nodules which overlies the Acre Limestone as in Caves Haven, but the limestone itself cannot be seen on the west side of the island.

The Low Dean Limestone and calcareous shale are found again to the eastward on the foreshore, opposite the Castle, so that either there are concealed undulations of the strata along this southern coast of the island, or the beds are repeated by a fault

which must be in the bay called The Ouse. For the list of fossils collected opposite the Cathedral and near the Castle, see p. 23.

There is an almost continuous section along the foreshore of the eastern side of the island between Scar Jockey and Emmanuel Head. The rocks exposed seem to consist principally of sandstones lying nearly flat or having a gentle easterly dip. Near Broad Stones there are in places many large angular blocks of limestone, so it seems probable that a thin limestone bed is found here among the sandstones. Shale appears to overlie this bed, and above this comes a grey and reddish blocky sandstone with a gentle dip to the eastward. There is a trace of coal below the supposed limestone, and there succeeds to the westward soft micaceous sandstone, shaly in places. The sandstone near the shore which underlies this is occasionally coarse, as at Sheldrake Pool and opposite the Bride's Hole, in the cliff. Farther north, at the south end of Red Brae, very coarse sandstone in the cliff rests upon shale, while at one place there is a coal which varies from 2 or 3 to 10 inches in thickness, and there are traces of a coal-seat on the foreshore some distance to the eastward. On the raised beach south of Sheldrake Pool there is an old sandstone quarry in which a coal is said to have been found. On this same raised beach are many circular shallow pits which look much like the mouths of old shafts, but which are said to be places where kelp was burnt.

CHAPTER VI.—CARBONIFEROUS—*continued.*

PALEONTOLOGY OF THE LIMESTONE GROUP.

Now that attention is being paid to the question of horizons in the Carboniferous Rocks, and that a committee of the British Association has been formed to prosecute enquiries into the subject, it seems advisable to give in a tabular form complete lists of fossils from all the more important of the limestones separately, so far as they have been collected from by the Geological Survey. To make the Tables more complete some fossiliferous localities from adjoining areas are included, but none are admitted about which there is any doubt as to the identity of the limestones apart from fossil evidence. Of course, these fossil lists are far from complete, but the lists may be accepted as genuine contributions towards the life-history of each particular limestone in the localities mentioned. In the *Appendix* will be found a classified list of all the fossils collected in this area by the Geological Survey, with reference to the localities, in addition to which are lists of fossils collected in the district by other observers.

The evidence so far goes to show that not one of the limestones of this area can be said to have what are called characteristic fossils, *i.e.*, fossils that are found on only one horizon. Again and again the same forms recur from the bottom to the top of the series, and if we could give lists from the limestones which in other places come above the Dryburn Limestone, no doubt we should find a repetition of the evidence supplied by these. There are, however, groups of fossils which characterize certain beds locally, *e.g.*, No. 4 Limestone abounds in Pelyzoa; the Woodend, No. 1, and No. 4, are rich in Corals; No. 3, or the Acre, is generally distinguished by its numerous Entomostraca; and so on. When traced over large areas, however, the limestones are found to lose some of their characters. Prof. Lebour thought that *Succammina Carteri* characterized the 2nd or Eight Yard Limestone, whereas in this area it is No. 3 in which this foraminifer abounds. There are some fossils that are unique so far as this area is concerned. *Nuculana (Leda) attenuata?* from the Grey Mare quarry is one of these, and from the Elford quarry (not given in the Tables on account of uncertainty about its horizon) are enumerated *Microdoma quadriserrata*, *Porellia*, and *Cyrtoceras rugosum*. No conclusions of course can be drawn from a single occurrence of any one species. It only shows how incomplete our lists are.

Posidonomya Becheri is an interesting form. So far as is known it does not occur below the Oxford Limestone, and is therefore confined to beds which represent the Yoredale Series. It is reported from four different localities, viz., Eudle (Heather-

house, on the shore), the shore west of Budle, Glororum, and Easington Grange Mill, near Elwick, and in each case it is difficult to fix the exact horizon of the bed in which it occurs; but probably all are above the Oxford Limestone.

In the lists of fossils from No. 1 Limestone it must be remembered that Scremerston New Quarry is not in this Sheet but in 110 N.E. Similarly, the Scremerston locality in No. 2 is in the same Sheet. The Oxford Quarry in lists of No. 5 Limestone, is also in 110 N.E. Dunsall Quarry is in 110 S.W., and so are the Winterburn and Woodend Quarries of No. 6 Limestone.

The letters D and W prefixed to certain names indicate that these fossils range upwards from the Dun and Woodend Limestones respectively.

The Ostracoda which were collected by Mr. J. Bennie, from some of the localities, were named by Mr. Kirkby.

FOSSILS from No. 1 Limestone.

	LOCALITIES.		
	New Dryburn Quarry.	Scremerston New Quarry.	Beaumont Shore.
W. Alveolites septosa, <i>Flem.</i>	x	x	x
W. " depressa, <i>Flem.</i>			x
Amplexus coralloides, <i>Sow.</i>	x ?		
W. Cyathophyllum Murchisoni, <i>M. Edw.</i>	x		
" regium, <i>Phil.</i>	x ?		
Cyclophyllum fungites, <i>Flem.</i>		x	
D. W. Lithostrotion junceum, <i>Flem.</i>	x ?	x	
" Lonsdaleia floriformis, <i>Mart.</i>	x		x
W. Syringopora geniculata, <i>Phil.</i>	x ?		x
W. " ramulosa, <i>Goldf.</i>	x ?		
" reticulata, <i>Goldf.</i>			x
Entomostraca -	x		
Phillipsia Eichwaldi, <i>Fisch.</i>	x		
Rhabdomeson rhombiferum, <i>Phil.</i>	x		x
D. Chonetes laguessiana, <i>De Kon.</i>	x		x
W. Athyrus Roissyi, <i>L'Eveillé</i>	x ?		x
D. W. Productus giganteus, <i>Mart.</i>	x	x	x
" fimbriatus, <i>Sow.</i>	x		x ?
" humerosus, <i>Sow.</i>			x
W. " longispinus, <i>Sow.</i>	x		
" punctatus, <i>Mart.</i>	x		
W. " semireticulatus, <i>Mart.</i>	x	x	
Rhynchonella pleurodon, <i>Phil.</i>	x		
W. Spirifera (Reticularia), lineata, <i>Mart.</i>	x		
W. " trigonalis, <i>Mart.</i>	x	x	
D. W. Streptorhynchus crenistria, <i>Phil.</i>	x	x	
Terebratula (fragment)	x		
Aviculopecten coelatus, <i>McCoy</i>	x		
Leptodomus fragilis, <i>McCoy</i>	x ?		
Nucula gibbosa, <i>Flem.</i>	x		
Schizodus	x		
Bellerophon (Euphemus) Urei, <i>Flem.</i>	x		
Euomphalus carbonarius, <i>Sow.</i>	x		
W. Loxonema rugifera (cast), <i>Phil.</i>	x		

FOSSILS from No. 2 Limestone.

	LOCALITIES.			
	Scremerston.	Holy Island, N.	Holy Island, S.	Lowick.
D. W. Lepidodendron sp.	x			
Lithostrotion junceum, <i>Flem.</i>	x			
Zaphrentis (from Beadnell)				
Crioid (stems)	x	x		
Poteriocrinus (stems)	x		x	
crassus, <i>Mill.</i>				
Bairdia brevis, <i>J. & K.</i>	x			
" plebeia, <i>Reuss.</i>	x			
" subelongata, <i>J. & K.</i>	x			
Beyrichia radiata, <i>J. & K.</i>	x			
Bythocypris cuneola, <i>J. & K.</i>	x			
cornigera, <i>J. & K.</i>	x			
Leperditia Okeni, <i>Mün.</i>	x			
*Griffithides (glabella)			x	
Phillipsia Eichwaldi, var. mucronata, <i>Fisch.</i>			x	South Moor.
Phillipsia Eichwaldi, var. mucronata (Lowick South Moor.)			x	x
Polyzoa (fragt.)				x
Fenestella plebeia, <i>M'Coy</i>				x
W. Athyris ambigua, <i>Sow.</i>	x ?	x	x	x ? South Moor.
W. " Roissyi				x
Athyris (fragt.)				
Chonetes laguessiana, <i>De Kon.</i>			x	
*Discina nitida, <i>Phil.</i>	x		x	
*Lingula squamiformis, <i>Phil.</i>	x		x	
Orthis Michelini (fragt.), <i>L'Eveillé</i>			x	
resupinata, <i>Mart.</i>				x
Productus aculeatus, <i>Mart.</i>	x	x		x
D. W. " giganteus, <i>Mart.</i>	x	x		
W. " longispinus, <i>Sow.</i>	x	x		x
" punctatus <i>Mart.</i> var elegans, <i>M'Coy</i> (from Beadnell).	x	x		
W. " semireticulatus, <i>Mart.</i>	x		x	-
" youngianus ? <i>Dav.</i>				x
Rhynchonella pleurodon, <i>Phil.</i>	x		x	
Spirifera glabra, <i>Mart.</i>	(fragt.)	x ?		South Moor.
trigonalis, <i>Mart.</i>	x	x		x
Spiriferina laminosa ? <i>M'Coy</i>	x	x		x
Streptorhynchus crenistria, <i>Phil.</i>	x	x		x
Dielasma (Terebratula) hastata <i>Sow.</i>				x
Aviculopecten semicircularis, <i>M'Coy</i>	x			
Cardiomorpha ? sp.			x	
*Edmonia sulcata ? <i>Phil.</i>	x		x ?	
Leptodomus costellatus, <i>M'Coy</i>			x	
Nucula undulata, <i>Phil.</i>	x			
Pecten Sowerbyi, <i>M'Coy</i>				x x

FOSSILS from No. 2 Limestone—*continued.*

	LOCALITIES.			
	Scremerston,	Holy Island, N.	Holy Island, S.	Lowick.
<i>Pinna flabelliformis</i> , <i>Mart.</i> (<i>flexicostata</i> , <i>M'Coy</i>).	x			
* <i>Schizodus</i> (<i>Axinus</i>) sp.			x	
<i>Solenya primæva</i> , <i>Phil.</i>	x			
<i>Bellerophon</i> (<i>Euphemus</i>) <i>decssatus</i> (fragt.), <i>Flem.</i>	x ?			
<i>Bellerophon</i> (<i>Euphemus</i>) <i>interlineatus</i> , <i>Portl.</i>			x	
<i>Dentalium</i> (<i>Entalis</i>) <i>priscum</i> , <i>Münst.</i>			x ?	
<i>Euomphalus</i> (fragt.)			x	
<i>Loxonema</i> ?				x
<i>Pleurotomaria</i> (fragt.)	x			
<i>Turbo</i>			x	x
<i>Goniatiite</i> (fragt.)			x	
<i>Nautilus</i>	x			
<i>Actinoceras gigantens</i> , <i>Sow.</i>	x	x		
<i>Orthoceras sulcatum</i> , <i>Flem.</i>			x	
<i>Fish</i> (fragt.)	x	x		
<i>Petalodus</i>				x

Under Holy Island South, those marked with an * came from the shore near the Castle; the others came from south of the Cathedral.

The Lowdean quarry, Lowick, is south of the Dryburn quarry.

FOSSILS from No. 3 Limestone.

	LOCALITIES.		
	Dun Quarry, Lowick.	Quarry N.E. of Bowsden.	Ancroft- steads Quarry.
<i>Palaeacis cyclostoma</i> , <i>Phil.</i>		x	x
<i>Saccammina Carteri</i> , <i>Brady</i>		x	x
Coral"	x		
W. <i>Alveolites septosa</i> , <i>Flem.</i> (on <i>Cyathophyllum</i>)	x		
W. <i>Michelinia favosa</i> ? <i>Goldf.</i>		x	
W. <i>Monticulipora tumida</i> , <i>Phil.</i>	x	x	x
W. <i>Zaphrentis Phillipsi</i> , <i>M'Edw.</i>		x ?	x
" Crinoid plates	x		
W. <i>Poteriocrinus nuciformis</i> , <i>M'Coy</i> (stems)	x	x	x
Rhodocrinus		x	x
Worm burrows (or throws)			x
Bairdia ampla, <i>Reuss.</i> (good and common in Ancroftsteads)	x		x
" brevis, <i>J. & K.</i>	x		
" <i>Hisingeri</i> , <i>Münst.</i>			x
" plebeia, <i>Reuss</i>	x		x
" <i>subelongata</i> , <i>J. & K.</i>			x

FOSSILS from No. 3 Limestone—*continued.*

	LOCALITIES.		
	Dun Quarry, Lowich.	Quarry N.E. of Bowsden.	Ancroft- steads Quarry.
Bairdia, submucronata, <i>J. & K.</i> (var. punctata in Ancroft- steads).	x ?		x
Bythocypris (<i>Cythere</i>) bilobata, <i>Münst.</i>	x ?		x
" <i>Phillipsiana</i> , <i>Jones</i> & <i>Holl.</i> , var <i>car-</i> <i>bonica</i> , <i>J. & K.</i>	x		
Ulrichia bituberculata, <i>M'Coy</i>	x		
Beyrichia radiata, <i>Jones</i> & <i>Kirkby</i>	x		
Bythocypris cornigera, <i>J. & K.</i> <i>cuneola</i> , <i>J. & K.</i>	x		x
Cytherella scrobiculata, <i>J. & K.</i>	x		x
" <i>recta</i> , <i>J. & K. & B.</i>	x		
" ? <i>reticulosa</i> , <i>J. & K.</i> sp.	x		
" <i>Kirkbya permiana</i> , <i>Jones</i>			x
" <i>umbonata</i> , <i>D'Eichwald</i>			x
" <i>Urei</i> , <i>Jones</i>			x
Leperditia <i>Okeni</i> , <i>Münst.</i> (very small).	x		
Dithyrocaries <i>Colei</i> , <i>Portl.</i> (buccal plates).	x		x
" buccal plates		x	
Griffithides <i>longiceps</i> , <i>Portl.</i>			x
Phillipsia <i>Eichwaldi</i> , <i>Fisch.</i>	x		
Polyzoa (fragt.)			x
Fenestella <i>carinata</i> ? <i>M'Coy</i> ,, <i>membranacea</i> , <i>Phil.</i> (<i>Beadnell</i> ?).	x		
Glauconeome ?	x		
Rhabdomeson	x		
Athyris <i>Roissyi</i> , <i>L'Evcillé</i>		x ?	x
Chonetes <i>buchiiana</i> , <i>De Kon.</i>	x	x	x
" <i>laguessiana</i> , <i>De Kon.</i>	x	x	x
Discina <i>nitida</i> , <i>Phil.</i>	x	x	
" <i>Lingula mytiloides</i> , <i>Sow.</i>			x
Orthis <i>Michelini</i> , <i>L'Eveillé</i>			x
Productus <i>costatus</i> , <i>Sow.</i>	x		
" <i>giganteus</i> , <i>Mart.</i>	x	x	
" <i>longispinus</i> , <i>Sow.</i>	x	x	x
" <i>pustulosus</i> , <i>Phil.</i>	x		
Spirifera <i>glabra</i> ? <i>Mart.</i>	x	x	
" <i>trigonalis</i> , <i>Mart.</i> (fragt.)	x	x	x
Spiriferina <i>insculpta</i> , <i>Phil.</i>		x	x
Vucula <i>brevirostris</i> ? <i>Phil.</i>	x	x	x
" <i>gibbosa</i> , <i>Flcm.</i>	x	x	
Leptodomus (<i>Sanguinolites</i>) <i>costel-</i> <i>latus</i> , <i>M'Coy</i> .	x		
Sanguinolites <i>variabilis</i> ? <i>M'Coy</i>		x	
Bellerophon (<i>Euphemus</i>) <i>decussatus</i> , <i>Flem.</i>	x		
" <i>Urei</i> , <i>Flem.</i>	x	x	x
Dentalium (<i>Entalis</i>) <i>priscum</i> , <i>Münst.</i>	x		x
Euomphalus <i>carbonarius</i> , <i>Sow.</i>	x	x	x

FOSSILS from No. 3 Limestone—*continued.*

	LOCALITIES.		
	Dun Quarry, Lowick.	Quarry N.E. of Bowsden.	Ancroft- steads Quarry.
<i>Loxoneima rugifera</i> , <i>Phil.</i>	x (fragt.)		x
<i>Macrochilina</i>			x
<i>Pleurotomaria</i> (<i>Ptychomphalus</i>)	x		x
<i>atomaria</i> , <i>Phil.</i>			x
<i>Pleurotomaria</i> (<i>Ptychomphalus</i>)			x
<i>intertrialis</i> , <i>Phil.</i>			x
<i>Pleurotomaria</i> (<i>Mourlonia</i>) <i>nati-</i>			x
<i>coides</i> , <i>De Kon.</i>			x
Goniatite			x
<i>Orthoceras cinctum</i> , <i>Sow.</i>		x	
“ <i>reticulatum</i> , <i>Phil.</i>	x		
“ <i>sulcatum</i> , <i>Flem.</i>	x	x	x
Fish teeth			x
<i>Helodus</i>	x	x	x
<i>Pristicladodus</i> ?	x		
<i>Archæocidaris</i> , (Holy Island).			

FOSSILS from No. 4 Limestone.

	LOCALITIES.					
	Eelwell, Lowick.	Bowsden.	Beal Point.	North Sunder- land.	Beadnell Shore. Quarry.	
<i>Saccammina Carteri</i> , <i>Brady</i>	x			x		x
Coral				x		
W. <i>Alveclites depressa</i> , <i>Flem.</i>	x		x	x		
<i>Aulophyllum</i> ?					x	
<i>Cyathophyllum</i> ?					x	
“ <i>Archiaci</i> ? <i>M'Edw.</i>	x					
<i>Lithostrotion irregularare</i> , <i>M'Edw.</i>	x					
W. “ <i>juncuum</i> , <i>Flem.</i>	x	x	x	x		
W. <i>Monticulipora tumida</i> , <i>Phil.</i>	x	x	x	x		x
<i>Syringopora</i> (fragt.)	x					
W. “ <i>geniculata</i> , <i>Phil.</i>			x?		x	
W. “ <i>ramulosa</i> , <i>Goldf.</i>					x	
Zaphrentis				x		x
Crinoid stems	x			x	x	x
Actinocrinus				x	x	x
Platycrinus ?				x	x	x
Poteriocriinus (stems)	x			x	x	x
<i>Phillipsia Eichwaldi</i> , <i>Fisch.</i>				x	x	x
“ (tail of)					x	x
<i>Diastopora megastoma</i> , <i>M'Coy</i>	x				x	
“ <i>tumida</i> , <i>Phil.</i>					x	
<i>Fenestella carinata</i> , <i>M'Coy</i>				x	x	x
“ <i>Glaucome</i>				x	x	x
<i>Polypora dendroides</i> , <i>M'Coy</i>	x					
<i>Pustulopora spicularis</i> ? <i>Phil.</i>	x					
<i>Retepora</i>						
<i>Rhabdomesos gracile</i> , <i>Phil.</i>				x		x
“ <i>rhombiferum</i> , <i>Phil.</i>				x		
<i>Vincularia</i> (<i>Suicoretepora</i>) <i>raricosta</i> ,				x		
“ <i>M'Coy</i> .						
<i>Athyris ambigua</i> , <i>Sow.</i>	x			x		
“ <i>Roissyi</i> , <i>L'Eveillé</i> |	x		x	x	x?	x
“ sp.						
<i>Camarophoria crumeua</i> ? <i>Mart.</i>				x		

FOSSILS from No. 4 Limestone—*continued.*

	LOCALITIES.					
	Eelwell, Lowick.	Bowsden.	Beal Point.	North Sunder- land.	Beadnell.	
	Shore.	Quarry.				
<i>Chonetes Lagnessiana</i> , <i>De Kon.</i>	x			x	x	x
<i>polita</i> , <i>M'Coy</i>						
<i>Discina nitida</i> , <i>Phil.</i>		x		x	x	x
<i>Orthis Michelini</i> , <i>L'Eveillé</i>	x	x		x	x	x
<i>resupinata</i> , <i>Mart.</i>						
<i>Productus costatus</i> , <i>Sow.</i>			x	x		
<i>fimbriatus</i> , <i>Sow.</i>	x		x	x		
<i>gigantens</i> , <i>Mart.</i>	x	x	x	x	x	x
<i>longispinus</i> , <i>Sow.</i>		x		x	x	x
<i>punctatus</i> , <i>Mart.</i>	x			x		
<i>pustulosus</i> , <i>Phil.</i>				x		
<i>scabriculus</i> , <i>Mart.</i>				x	x	x
<i>semireticulatus</i> , <i>Mart.</i>	x		x	x	x	x
<i>youngianus?</i> <i>Dav.</i>				x		
<i>situtus</i> (<i>Hentonsteads</i>)				x		
<i>spinulosus</i> (<i>Hentonsteads</i>)						
<i>Rhynchonella acuminata?</i> <i>Mart.</i>			x	x		
<i>Spirifera glabra</i> , <i>Mart.</i>	x			x?		
<i>grandicostata?</i> <i>M'Coy</i>	x					
<i>(Reticularia) lineata</i> , <i>Mart.</i>	x					x?
<i>trigonialis</i> , <i>Mart.</i>	x	x	x	x	x	x
<i>Streptorhynchus crenistria</i> , <i>Phil.</i>	x					
<i>Dielaasma</i> (<i>Terebratula</i>) <i>gillingensis</i> , <i>Dav.</i>	x					
(fragt.)						
<i>Aviculopecten</i>					x	
<i>Edmondia sulcata?</i> <i>Phil.</i>						
<i>Leptodomus</i> (<i>Sanguinolites</i>) <i>costellatus</i> , <i>M'Coy</i>					x	x
<i>Modiola</i> (<i>Lithodomus</i>) <i>Jenkinsoni</i> , <i>M'Coy</i>	x					
<i>Modiola</i> sp.		x				
<i>Myalina</i> sp.		x	x			
<i>Pleurorhynchus</i> (fragt.)		x				
<i>Sanguinolites oblongus</i> , <i>Portl.</i>				x		
sp.				x?	x	x?
" <i>Bellerophon cornuarientis</i> , <i>Sow.</i>						
<i>Enomphalus carbonarius</i> , <i>Sow.</i>				x?	x	x?
<i>Naticopsis elongata</i> , <i>Phil.</i>					x	x
<i>plicistria</i> , <i>Phil.</i>						x
<i>Naticopsis</i>						
<i>Pleurotomaria</i> (<i>Baylea</i>) <i>Yvani</i> , <i>L'Eveillé</i>	x				x	x
<i>Actinoceras</i>						
<i>Discites</i>	x			x		
<i>Nautilus</i> (fragt.)		x				
<i>Orthoceras sulcatum</i> , <i>Flem.</i>					x	
(fragt.)			x			
<i>Fish teeth</i>	x				x	x
<i>Psammodus</i>						

FOSSILS from the Oxford Limestone.

	LOCALITIES.					
	Oxford.	Dunstable.	Swinhoe.	Annstea.	Greenhill Rocks.	Monks- house.
<i>(Saccammina Carteri</i> , <i>Brady</i> (<i>Moss Hall quarry</i>)).						
<i>Alveolites depressa</i> , <i>Flem.</i>	x	x			x	x
<i>Cladochonus?</i>			x			
<i>Coral</i>						
<i>W. Cyathophyllum Murchisoni</i> , <i>M'Edw.</i>	x	x		x	x	x
(near Coldrife)						
<i>Lithostrotion irregulare</i> , <i>M'Edw.</i>				x	x	x
<i>W.</i> " <i>juncatum</i> , <i>Flem.</i>		x		x		x
<i>Lonsdaleia juncea</i>					x	x
<i>W. Monticulipora tumida</i> , <i>Phil.</i>		x			x	x
<i>Syringopora</i>						
<i>Zaphrentis cylindrica</i> , <i>Scouler</i>					x	x

FOSSILS from the Oxford Limestone—continued.

	LOCALITIES.					
	Oxford.	Dunball.	Swinhoe.	Annstead.	Green-hill Rocks.	Monks-house.
W. Zaphrentis Phillipsi, M'Edw.		x				
Archeocidaris (spine and plate)	x					
Crinoid stem	x		x			
Platycrinus					x	
Poteriocrinus (stenis) crassus, Mill.		x		x	x	x?
Spirorbis?	x					
Bairdia amputata, Kirkby	x					
" brevis, J. & K.	x					
" Hisingeri, Münst.	x					
" plebeia, Reuss.	x					
" subelongata, J. & K.	x					
" sp.	x					
Bayrichia radiata, J. & K.	x					
Bythocypris bilobata, Münst.	x					
Kirkbya permiana, Jones	x					
" umbonata, D'Eich.	x					
Leperditia Okeni, Münst.	x					
Fenestella	x					
Ceripora interporosa, Phil.		x			x?	
Diastopora megastoma, M'Coy.	x	x	x			
Rhabdomeson gracile, Phil.	x	x	x			
" rhombiferum, Phil.	x					
Chonetes laguessiana, De Kon.		x				
Orthis Michelini, L'Eveillé		x				
" resupinata, Mart.			x			
Productus giganteus, Mart.	x	x	x	x	x	x
" costatus, Sow.	x					
" longispinus (Keystone quarry).	x					
Spirifera trigonalis, Mart.		x				
Solemya primæva, Phil. (Hoppen & Coldrife).						
Ballerophon (Euphemus) decussatus, Flem.		x				
Loxonema		x				
Orthoceras					x	

FOSSILS from the Woodend Limestone.

	LOCALITIES.					
	Hetton Coal Houses.	Woodend.	Winterburn.	Chatton.	Barnmoor Red House.	Bellashill.
1. 4. Alveolites depressa, Flem.	x			x		
1. 3. " septosa, Flem.		x	x			
Aulopora (fragt.)			x		x	x
Cladochonus	x					
Clisiophyllum Bowerbanki, E. & H.	x?					
1. Cyathophyllum Murchisoni, M'Edw.				x		
Heterophyllia granata, Dunc.		x				x?
" granulata, Dunc.				x	x	x
1. 2. 4. Lithostrotion juncsum, Flem.	x	x	x	x?	x	x
" Phillipsi, M'Edw.			x?	x	x	x
" Portlocki, M'Edw.	x	x	x?	x	x	x
Michelinia	x					
3. 4. Monticulipora (Chætetes) tumida, Phil.		x		x	x	x
1. 4. Syringopora geniculata, Phil.	x	x?		x		
" ramulosa, Goldf.	x	x?		x		

FOSSILS from the Woodend Limestone—*continued*.

	LOCALITIES.					
	Hetton Coal Houses.	Woodend.	Winter- burn.	Chat- ton.	Barmoor Red House	Pells- hill.
3. <i>Zaphrentis Phillipsi</i> , M'Edw. <i>Archaeocidaris</i> (plates or spines) Urei, Flem.	x	x		x	x	x
<i>Eucrinite</i> (stems of)	-	x	x			x
<i>Poterocrinus</i> (stems of)	-	x	x	x	x	
<i>Rhodocrinus</i> (stems of)	-	x	x	x	x	
<i>Spirorbis pusillus Mart.</i> (= car- bonarius), caperatus, M'Coy.	-				x	
<i>Bairdia plebela</i> , Reuss.	-				x	
" <i>subelongata</i> ? (4 inch long), J. & K.	-				x	
" <i>subimbricata</i> , J. & K.	-				x	
<i>Bythocypris cuneola</i> , J. & K.	-				x	
<i>Cytherella</i> sp.	-				x	
4. <i>Diastopora megastoma</i> , M'Coy.	x			x	x	
<i>Fenestella</i>	-				x?	
2, 4. <i>Athyris ambigua</i> , Sow.	x	x			x?	
1, 2, 3, 4., Roissy, L'Eveillé.	x	x		x	x	
4. ? <i>Camarophoria crumenata</i> , Mart.	-					x?
3, 4. <i>Productus costatus</i> , Sow.	x?					
1, 2, 3, 4. " <i>giganteus</i> , Mart.	x	x	x	x	x	
1, 2, 3, 4. " <i>longispinus</i> , Sow.	x	x	x	x	x?	
3, 4. " <i>pustulosus</i> , Phil.	-				x?	
1, 2, 4. " <i>semireticulatus</i> , Mart.	x	x	x		x?	x
1, 4. <i>Spirifera lineata</i> , Mart.	-					
1, 2, 3, 4. " <i>trigonialis</i> , Mart.	x			x (fragt.)	x	
2. ? <i>Spiriferina laminosa</i> , M'Coy.	-		x?			
" <i>trigonalis</i> , Mart.	x					
1, 2, 4. <i>Streptorhynchus crenistria</i> , Phil.	x					x
<i>Strophomena rhomboidalis</i> var. analogia, Phil.	x					
<i>Aviculopecten</i> (imperfect)	x					
<i>Solemya primæva</i> , Phil.	x					x?
<i>Bellerophon tenuifascia</i> , Sow.	x					
1, 3. <i>Loxonema rugifera</i> , Phil.	x					
<i>Macrochilina ovalis</i> , M'Coy.	-					
<i>Naticopsis</i>	-					
<i>Orthoceras</i>	-	x				
Fish tooth	-		x			

The numbers 1, 2, 3, 4 prefixed to certain species indicate that the fossils range to Nos. 1, 2, 3 and 4 Limestones respectively.

FOSSILS from the Dun Limestone.

	LOCALITIES.			
	Cocken- heugh.	Grey Mare.	Linkey- law.	Twizell South Dean.
<i>Lithostrotion junceum</i> , Flem. (and South Moor Farm House.)				x
<i>Syringopora</i>	x	*		?
<i>Encrinite</i> stem	x			
<i>Griffithides</i>	x			
<i>Chonetes laguressiana</i> , De Kon.	-	x	x	
<i>Productus giganteus</i> , Mart.	x			
" <i>undatus</i> ? Defr.	-		x	
<i>Streptorhynchus crenistria</i> , Phil.	x	x (fragt.)		
<i>Strophomena rhomboidalis</i> , var analogia, Phil.	x			
<i>Nuculana (Leda) attenuata</i> ? Flem.		x		

No. 1 Limestone is the Dryburn Limestone of Lowick and the Ebb's Snook Limestone of Beadnell, and is called further south in Northumberland, the Ten Yard Limestone. It is the Main or Twelve Fathom Limestone of Wensleydale and Swaledale, and the Great Limestone of Teesdale and Weardale, and is the uppermost limestone of Phillips's Yoredale Series.

No. 2 Limestone is called at Lowick the Lowdean, and at Scremerton the Sandbanks Limestone. Generally in Mid-Northumberland it receives the name of the Eight Yard Limestone. It is called in north-west Yorkshire the Underset Limestone, and in Teesdale and Weardale the Four Fathom.

No. 3 Limestone is the Acre Limestone of Lowick, where it is also sometimes called the Dunstone, which name however must not be confounded with the Dun Limestone, the lowest of the marine limestones. Further south this limestone receives the name of the Six Yard Stone, and in Weardale and Teesdale it is called the Three Yard. It is the Little Limestone in the Wensleydale Section—there 12 ft. thick.

No. 4 Limestone is the Eelwell of Lowick, and the Main Limestone of Beadnell and North Sunderland. Further south in Northumberland it is called the Nine Yard. In Weardale and Teesdale it is the Five Yard, and in Swaledale it goes by the name of the Third Set of Lime. In Wensleydale it is called the Fossil Lime.

These four limestones, with the intermediate strata, form the group of limestones at Cat Craig near Dunbar, which is the lower division of marine limestones in Scotland, and these therefore represent only the upper part of Phillips's Yoredale Series.

The limestones numbered 1 to 4 have been traced almost continuously for nearly 100 miles, and therefore we are certain of their identity, but the limestones below these have not been so traced and there is some uncertainty about their exact correlations. It seems probable however that the six comparatively thin limestones, ranging from 5 to 10 ft. each, between the Eelwell and the Oxford, represent the Scar, Cockleshell, Singlepost, and Tynebottom Limestones of Weardale and Teesdale, and that the Oxford Limestone is on the horizon of the Hardraw Scar or lowest bed of Phillips's Yoredale Series of limestones.

This much is certain, that the Woodend and the Dun Limestones are far below this horizon and represent portions of the Mountain Limestone or Great Scar Limestone of Ingleborough. The Woodend Limestone is called in the Alnwick district the Hobberlaw Limestone, and in the Otterburn and Redesdale districts the Fourlaws Limestone, while the Dun Limestone is identical with the Redesdale Limestone. In Scotland generally these lower marine limestones, from the Eelwell downwards, are represented by the estuarine Calciferous Sandstone Series, except along the coast between Berwick-on-Tweed and Burnmouth (where the Lamberton Limestone is the Dun), and on the coast of Haddingtonshire and Berwickshire, between Innerwick and Cockburnspath.

CHAPTER VII.—INTRUSIVE IGNEOUS ROCKS.

BASALTIC WHIN SILL AND WHIN DYKES.

Whin Sill.

The intrusive sheets of Whin Sill, as they are called, which appear in this area, are but portions of a great intrusive igneous mass which is exposed at the surface nearly all across the county of Northumberland; it is found in the counties of Cumberland and Westmorland in the Pennine escarpment; and in the valleys of Weardale, Teesdale and Lunedale in Durham and north-west Yorkshire. Its northern limit is seen in the area at the Farne Islands and at Kyloe Cottage, while its southern limit nearly coincides with the northern side of Lunedale, Yorkshire, which is about 80 miles in a straight line from the outer Farnes.

It is a dark-grey or bluish-grey crystalline rock of a basic character, containing about 50 per cent. of silica, closely allied to basalt or dolerite; though Mr. Teall* declines to give it either of these names on account of the absence of olivine, and is inclined to class it with the diabases. Dr. F. H. Hatch describes a specimen from the Brownsman Island as a fine-grained basaltic rock, and one from Belford Crags as an enstatite-dolerite exactly similar to the rock described by Mr. Teall in his paper.

The bulk of the rock is generally of a medium coarseness, but it is nevertheless fine-grained in a good many places, especially in the thinner sheets, and near the junction with the rock into which it is intruded. It is also pretty often amygdaloidal, the cavities having been filled with quartz or calcite.

The main portion of the Whin Sill enters this area from the south near Newton-by-the-Sea, and runs out into Newton Point. It lies here a little below the Dryburn or Ten Yard Limestone (the Great Limestone of Teesdale), being separated from it by a few feet of sandstone. On the northern side of the whin at extreme low water there is visible a mass of thin sandstone included in it, about 12 ft. long and 6 ft. thick, dipping N.E. at 40° , while the general dip of the beds, including the whin, is S.E. at about 5° . There is a roll over of the beds immediately to the north, and the whin is seen again on the foreshore, this time close under the limestone, which dips N.W. at 15° . On the north side of the bay the limestone comes up again at the Snook with a south-easterly dip of 5° , and the whin is again immediately below it, except for a distance of 70 yds. near the shore, where there is a strip of sandstone 2 to 3 ft. thick next to the limestone. The whin runs out to sea in Snook Point, where it has a bedded appearance. Its surface is fine-grained, and dips S.E. at 10° , and its lower part is amygdaloidal. Westwards it extends to Newton North Farm, where 7 to 8 ft. are

* *Quart. Journ. Geol. Soc.*, Vol. 40, p. 640.

exposed with an 18 in. sheet of nodular, rubbly, and amygdaloidal rock in the middle. There is a detached mass of whin running through the farmsteading of Newton and west of the village. It seems to die out at the north end, but a little before doing so is as much as 20 ft. thick, resting on sandstone and having the same rock above it. Its intrusive character is well shown in one place, where it descends abruptly over the sandstone 3 ft. to 4 ft. It is probably nearly on the horizon of the other mass. There are three small areas to the westward, where it may be seen; and it appears in several rocks out at sea south of Beadnell Bay. Judging by the slope of the whin surfaces there is probably an anticlinal in the beds between Whittingham Carr and Robin Wood's Rock.

From Robin Wood's Rock to the Farne Islands, a distance of 5 to 6 miles, no whin is known. If there is any outcrop of it in this interval beneath the sea it would seem to pass above the Dryburn Limestone, as none appears in the Beadnell section. There must be several sills on the Farnes on different horizons, and it is evident that both the sills and the rocks into which they are intruded are undulating a good deal, or nearly flat in some cases.

As there are not many outcrops of non-igneous rock on the Farnes I shall give instances of the slope or dip of the whin surface, as this generally indicates also that of the other beds. At Seal Gut, west of the Longstone, the surfaces dip S. and S.S.W.; at Humber Rock, north of the lighthouse the dip is N.E.; at Clove Carr the dip is N.; at Big Harcar, N.W.; at North Wamses, G.W.; at Roddam and Green, S.S.W. (this is S.E. of South Wamses). On the south side of the last is a small patch of quartzose sandstone, 4 to 5 yds. long, nearly surrounded by the whin. There is an evident synclinal on the Brownsman ranging from N.N.W. to N.W., and passing west of the Wamses. There are two patches of non-igneous rock on the Brownsman, which have been already noticed, and both are surrounded by whin. Staples Island seems certainly a lower sheet, dipping N.E. or N.N.E., and this must be at least 60 ft. thick at the S. end where are the fine columns called the Pinnacles.

It may be as well to mention that the Elbow, Islestone Shad, Glororum Shad, and the Fang, never appear above water.

At the ScarCars the surfaces dip E.N.E., and at the Wideopens to the N.E., and these seem all to be separate sheets. North of the Wideopens is the largest non-igneous patch seen in the islands. It lies east of the Kettle, and embraces two limestones and intermediate beds; these limestones are probably the Eelwell and the thin limestone below it, so that the whin is here, as G. Tate pointed out, nearly 400 ft. below its horizon at Newton-by-the-Sea. The greatest thickness the whin can be seen to have on the islands is on the Farne or Inner Island, where the fine columns at the south end of the island must be 70 to 80 ft. high. The thickness is probably more than this. The surface of the Farne dips to the N.E. so that the sheet which forms it is probably the lowest on the islands. The whin of the islands is much fissured,

the best marked joints or breaks running in a direction between 30° and 35° W. of N.

The whin forms the low rock called Islestone, on the shore west of Bamburgh, where the surface slopes to the N.W., and also the greater part of the rock on which stands Bamburgh Castle, where a well is sunk 75 ft. through the whin. The eastern side of the Castle Rock is hidden by blown sand, but on the western side sandstone and shale are visible below the whin in several places. The beds have a gentle dip to the N. or N.N.E., though in one place there is a piece of sandstone nearly enclosed in the whin and dipping at an angle of 40° . At the north end of the rock the base of the whin descends to the sea-level, and the cliff it forms affords a marked exhibition of the vertical jointing and semi-columnar structure so characteristic of the rock.

From near Bamburgh the whin takes a course, first S.W. to Spindleston, then westward to Belford, and lastly N.W. to the Kyloe Hills.

No whin or other rock is seen on the shore for about 500 yds. north-west of Bamburgh Castle, but after passing the Boathouse we find whin occupying the foreshore, with many inclusions of sandstone and shale. The whin and associated rocks are nearly flat or have a gentle dip eastward, though some of the inclusions are marked exceptions. For instance, the first inclusion reached is a mass of sandstone 11 yds. long dipping at a high angle to the N.N.E. A little further north is observed a group of six inclusions, of which Fig. 6, p. 71, gives a plan. This is near a vein ranging E.N.E., on the north side of which but further out from shore are other inclusions. Still further north, and at low-water mark, is a great mass of indurated shale which extends for 150 yds., in which occurs a dyke-like piece of whin 16 yds. in length. This shale perhaps overlies the whin here, for the fine whin to the north has thin pieces of indurated shale on it, and to the west of this, and south of the Harkess Rocks, is another mass of the shale surrounded by whin. The Harkess Rocks have several times been described by G. Tate and others, but most of the accounts and sections accompanying seem very fanciful. In fact the section is so complicated and the details are many of them of so minute a character that no plan or section, unless on a very large scale, can give a faithful representation of the remarkable instances of intrusion here to be observed, some of which seem to have been mistaken for dykes. For examples of several of these intrusions, see Chapter V., on the Limestone Series, p. 72.

On the south side of Newtown Hill, W.N.W. from Bamburgh, there are several parallel features in the whin running N.W., and possibly there may be here intercalated some thin sedimentary patches. At the fine crags of Spindleston, crowned by an old camp, the thickness is probably 100 ft. To the north of this and east of Waren Mill there is a crag on the dip side, which is not a usual thing. There is only a rather narrow band of the whin visible west of Waren Mill, and it is probably thin, and there may be a break in it west of Chesterhill. It thickens again

westward in Long Hills before coming to an end west of Farhill Crags. To the north of this sets in another sill, probably on a higher horizon, at Harper's Heugh; and this runs west by Kippy Heugh and Easington to Crag Mill, where it encloses some limestone. After crossing the railway it turns southward and dies out apparently near the Turret in the grounds of Belford Hall. It appears again north of Belford Hall, and spreads over a wide surface, and turning to the N.W. forms the Chapel Crag with a fine scarp facing the west; continues to Middleton, and north of it spreads out largely south of Heugh Plantation. There are a good many isolated patches to the eastward—one cut through by the railroad seems faulted on the east side—and others, as the one west of Easington Grange, could only be traced by angular fragments turned up in draining and ploughing. At Middleton there are several interesting examples of intrusion, and of the alteration effected by the whin on the sedimentary strata. Several of these have been previously described in Chapter V. on the Limestone Series, *see p. 48.*

To the west of the Chapel Crag sill, besides several small outcrops there are three other whin sills on different horizons, forming Sunnyside Crag, north of Craggyhall, Penny Heugh, and Leigh Heugh, north of Plantation Farm; each of them having slopes to the east and steep scarps to the west. The last-mentioned runs to Detchant Buildings, but cannot be connected with the outcrops near Dick's Old Walls, at the east end of which the dip-surface slopes at 20° to the N.N.E., and is fine and amygdaloidal or vesicular, as is often the case with the whin at the upper surface. The sill north of Detchant Buildings has a wide undulating slope to the east and a crag to the west, but its outline is very irregular and there are several detached masses east and north of it. The sill forming Swinhoe Crags, to the westward, is much narrower in outline and has a more regular lenticular form, and crags of it overlooking Swinhoe Pond are very fine. The Sill to the westward where the Whin attains its highest point in this area at Fawcett Hill, 551 ft. must be below the limestone at the Grey Mare quarry and cannot be far from the horizon of the Fawcett Coal Seam. A section drawn eastward from this hill would show five distinct sheets of whin on different horizons, the highest of which cannot well be lower than the Oxford Limestone, or some 600 or 700 ft. above the lowest. This latter becomes the main sill northward, and near the S.W. corner of Detchant Wood encloses a patch of sandstone. West of the Grey Mare indurated shale and sandstone above the whin are seen in several places. There is a thin sill in Detchant Wood in Kettleburn, of which about 6 ft. are visible,* and at the head of this burn the principal sill is very thin. At Holburn Colliery the whin is between the Fawcet and Main coals. To the west of this the Whin may be faulted with the coal seams, but the fault is not a large one, and then we find two sills on somewhat

* This is described by Dr. Hatch as probably an altered tholeitic andesite composed of a mesh of small lath-shaped felspars, the meshes filled with calcite probably representing decomposed augite.

different horizons which become one at Shiellow Crags, and this seems nearly to die out beyond the quarry before reaching the fault. Here occurs a very large fault by which the whin and the sedimentary beds are shifted a mile or so to the N.E. beyond Bogle Houses. On the S.E. side of this fault however, in Kyloe Wood, there is another sill on a much higher horizon, forming Uffa Hill, which has a dark limestone overlying it. This sill thins out rapidly at the eastern edge of the wood, but comes out again in several elongated bosses further east. It must be between the Oxford and Eelwell Limestones. The mass at Buckton is probably also about this horizon. It is of the usual blue-grey character and its surface dips to the north. Near Bogle Houses is a small quarry by the roadside which exposes the base of the whin, much decomposed, resting on 4 to 5 ft. of indurated fine sandstone and shale, which overlie white sandstone. West of this the whin is seen clearly to descend in the beds, cutting across several well-marked outcrops of sandstone and shale, the shale being altered. This is one of the most striking instances on a large scale of the intrusive character of the whin, and the upper surface crosses and descends in a like manner, the shale being indurated. Westward come the fine semi-columnar crags of the Kyloe Hills, but the rock on which the whin rests is not here seen. To the northward however is a little spur of whin running out where it is seen to overlie sandstone, and not pass under it as one would expect. At the north end of the crags altered shale overlies the strip of whin just before it disappears. A fault may come through the hollow at the north end of the plantation, but the whin on the north side of the hollow fingers out before reaching the fault, so that the fault may be older than the intrusion of the whin. In the large quarry in the wood near Kyloe Cottage the bottom of the whin seems to have been reached, for black tills are said to be found below in places, and bastard whin or the decomposed rock rises up. This seems to be the most northern point the Whin Sill reaches.

There is only a trace of whin to be found on the west side of the great anticline. This is seen on the west side of the road leading to Holburn, 600 yds. south of the cross roads, and where a small stream crosses. Here are some old whin quarries, and the whin appears to be dipping westward, like the sedimentary rocks, which dip west at 45° . Judging by the outcrop it is probably about 10 to 12 ft. thick, and it certainly lies below the Scremerston Main Coal, which has been worked to the west of it. This is probably the lowest horizon it reaches. In the burn immediately east of Kyloe Cottage is a thin whin sill on a somewhat higher horizon. It is seen for a length of 25 yds. along the burn, and is about 1 ft. thick.

There seems to be a bit of intrusive whin in place at the Sithering (bubbling) Well, a quarter of a mile east of Holburn, which is perhaps a small sheet. Dr. Hatch, who had a specimen sliced, describes it as basalt, consisting of augite penetrated by lath-shaped crystals of felspar, and granules of magnetite;

and as ophitic in structure, with interstitial matter in occasional patches.

General considerations.—It is unnecessary to give here the titles of the numerous papers that have been written on the Whin Sill by Sedgwick, Phillips, Winch, Hutton and Trevelyan in the early part of the century, and by others in more recent times. Many of them will be found in the *Appendix*. The intrusive character of the whin was well shown, as far as Teesdale is concerned, by Prof. Sedgwick, and has been proved for this district in several papers by the late Mr. G. Tate of Alnwick.* Its intrusive character is now generally admitted, though many of the older writers, including Phillips, regarded it as non-intrusive. In the area embraced in this Sheet it has been shown that it ranges from the horizon of the Dryburn or Great Limestone down to below that of the Scremerston Main Coal, through a thickness of about 1,500 ft. of strata.†

Its upper surface is usually a dip-slope like that of the sedimentary beds into which it has been intruded, but exceptions occur where there is a crag instead of a gentle slope, e.g., north of Kyloe Hill (this has been mentioned before); north of Craggy-hall; north of Belford Hall; North of Harper's Heugh; and the case mentioned east of Waren House.

Several considerations lead one to suppose that in this district at all events its source lay to the south-eastward, and that in some instances it did not extend much farther to the west than its present outcrop. The whin exposed in one place on the west side of the Hetton Burn anticlinal, is much thinner than that on the east side, and to the westward, about Lowick and south of it, there is a repetition of all the beds, including those which elsewhere contain the Whin Sill, but there is no trace of the whin.

With regard to the age of the intrusion, I am inclined to refer it to the long period that elapsed between the deposition of the Carboniferous and Permian strata, between which there is a great unconformability indicating a great lapse of time. The following are the reasons:—

1. There is a marked resemblance in every respect between the rock forming the Whin Sill and that of the Hett Dyke, according to Mr. Teall, and the latter is very probably pre-Permian.
2. There are associated dykes and sills of much the same character in Scotland, and the dykes are plainly of late Carboniferous or of pre-Permian age. (*See* description of Sheet 23, Scotland.)
3. The Whin Sill is very unlike in character to the Cockfield or Cleveland Dyke, which cannot, we know, be earlier than the Oolites which it pierces.

* See "The Basaltic Rocks of Northumberland," *Proc. Ber. Nat. Field Club*, Vol. vi., 1871, pp. 197-217.

† Messrs. W. Topley and G. A. Lebour were misled by Boyd's paper into stating that the Whin Sill in this district reached a position far above the Great Limestone. *See* their paper in *Quart. Journ. Geol. Soc.*, Vol. xxxiii.

In this district the Whin Sill seems to be of nearly the age of the large N.E. faults. It is older than the large fault at Kyloe Plantation which throws it, but it certainly seems to be of later date than others, e.g., the large faults of Cockenheugh and Blagdondean, which are apparently older than the whin.

Whin Dykes.

These are of a basic character and mainly composed of felspar and augite. The Beadnell Dyke has not been described microscopically so far as I am aware.

Beadnell Dyke.—This dyke was described in 1812 by the Hon. H. G. Bennett. It runs in a direction slightly north of west, and is well seen for a length of about 500 yds. on the foreshore, where it stands up like a wall, cutting through the Low Dean, and Acre Limestones, and the intermediate beds. At its eastern end it is from 6 to 7 yds. wide, and at high-water mark 9 yds., but it cannot be traced far into the interior owing to the ground being drift-covered. It was found crossing the limestone quarries to the west, and is said to affect the stone for a distance of 20 ft. from the side, rendering it unfit for burning into lime. Bennett noticed the alteration it effects on the adjacent rocks, and the presence of iron pyrites and calcite near the junction. Whin is said to have been found in the fields north of Annstead Cottage, and there is a trace of whin on the south bank of the mill-race opposite to the farmsteading at Fleetham; this may be connected with the Beadnell dyke.

Two dykes of a similar character to that of Beadnell, and probably connected with it, have recently (1898) been exposed in a cutting on the new line of railway from Chathill to Sea Houses, opposite Fleetham. Both are composed of a bluish basic rock of a fine-grained character and somewhat amygdaloidal. The direction of both is the same; they cross the railway in a direction nearly E.N.E. The most northerly, which is the larger, is about 100 yds. south of the bridge at the smithy, and is from 10 to 12 ft. broad. It cuts through sandstone and shale, and the base of the sandstone rises a little to the dyke on the north side and dips very decidedly towards it on the south side, so that there is evidence of a disturbing force. A hundred yards farther south is the smaller of the two dykes, which is from 3 to 4 ft. in width. The sandstone adjacent to this is crushed and reddened, but the reddening may be the result of infiltration of iron along a crush-line.

Holy Island Dyke.—This is conspicuous along the south side of Holy Island at St. Cuthbert's Island, the Heugh, the Castle, and on the foreshore at Scar Jockey on the east side, and it forms the Plough Rock, half a mile from the shore, with the dangerous reef called the Plough Seat (of which portions are visible at very low tides) extending 500 yds. to the east of The Plough. Further out, about two miles from the land, it forms the Goldstone Rock. This shows 8 ft. above water at low tides, and extending east-

ward for nearly half a mile is another dangerous sunken reef with steep sides, the farthest extremity of which is called Steel End. At the Heugh on Holy Island this dyke rises to a height of 62 ft., and is 50 to 60 yds. wide, and at the Castle it is 70 yds. wide, and rises to 100 ft. above the sea. Its general direction is slightly to the north of east. Its general course, however, from the Plough to the Goldstone, is almost due east. South of the Heugh may be observed many examples of the alteration effected by its intrusion on the rocks it traverses; shale is baked and altered to a distance of 5 or 6 yds. from the side of the dyke, and limestone is rendered white and crystalline and bits of the altered rocks are found sticking to its sides. Winch, in his paper, published in 1822, notices the induration of the shales, the limestone caught up in the basalt, the presence of small veins and iron pyrites near the junction, &c.

Dr. Hatch, late of the Geological Survey, who has examined specimens under the microscope, describes it as a fine-grained Tholeite or a plagioclase-augite rock, intermediate in character between an andesite and an ophitic basalt. It passes into basalt, and consists of grains of brown augite partly penetrated by short lath-shaped crystals of plagioclase felspar, magnetite, and a dark-coloured turbid base.

There is no trace of this dyke on the shore at Fenham, but there is some indication of it in a field west of the railway to the north-east of Fenham Hill. From the south-west side of this hill it is clearly traceable for nearly a mile to the west side of Mount Hooly Dean. In a field on the west side of the main north road the dyke is seen to be divided, the northern branch being 3 to 4 yds. wide. In the quarry on the east side of the dean the dyke is very irregular and its intrusive character is clearly shown in a quarry represented in Fig. 8.

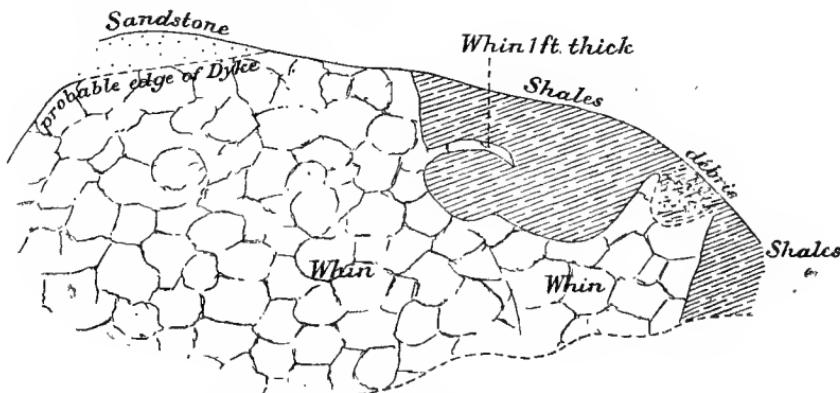


FIG. 8. Outline sketch of whin dyke in quarry at Mount Hooly Dean (South side). Section across direction of dyke.

This shows a nearly vertical surface at right angles to the general direction of the dyke. On the north side of the quarry sandstone is seen to overlie the whin, and on the south side, at a lower level, shale overlies it, while a small thin sheet about 1 ft.

thick juts out from the mass of the dyke into the shale. In the long quarry called Cockleman's Quarry, west of the dean, the dyke is about 12 yds. in width, and the sides are very irregular; the whin in places overlies the shale and sandstone, or sends branches into them, &c. The shales are indurated, and the coals burnt to cinders. This dyke, which has a course about 7° north of east, seems to die out just south of the east end of the Dean plantation.

Kyloe Cottage Dyke.—Another dyke starts close by the side of the stream, and 350 yds. north of the last described. It ranges through the wood in a direction 25° S. of W., and can be traced for half a mile to near Kyloe Cottage, where it seems to be 5 yds. or more wide; it is double that width at the east end of the plantation. It may continue further under the drift, west of Kyloe Cottage, and range parallel to the road here.

Kentstone Dyke.—About a quarter of a mile further north another dyke appears near Kentstone, which can be traced westward for 600 or 700 yds. Its course is somewhat wavy in outline, but the general direction is nearly W.S.W. and E.N.E. There is a quarry in it at Kentstone, where the dyke is 8 to 10 yds. wide, and indurated shale may be seen in the sides of the quarry. The dyke may extend a good deal farther westward, hidden by the thick boulder-clay about Hunting Hall.

Lickar Dean Dyke.—About a mile to the north of this line there is the Lickar Dean Dyke running in a parallel direction. It has been quarried in several places, and altered limestone and sandstone are visible near it. It can be traced for about half a mile, and clearly sends off a branch or divides into two dykes. It trends in the same direction as, and is probably continuous with, the dyke south of Bowsden, which can be followed westward for nearly three miles farther. There is some trace of whin which may be a dyke, at the Ordnance Station Δ 160, south of Mount Hooly.

All these dykes between Bowsden and Holy Island have been generally spoken of as one and the same, and represented on maps by a continuous straight line. From the foregoing description it will be seen how wide this is of the truth, as far as the dykes appear at the surface, though of course they may be connected below. The dyke of Cockleman's Quarry may well be considered as part of the Holy Island Dyke, being in the line of it. I could find no trace of any dyke at the Harkess Rocks, Bamburgh, except some dyke-like protrusion of the Whin Sill.

CHAPTER VIII.—FAULTS.

THERE is a remarkable series of large faults having a general parallelism and ranging nearly in a N.E. and S.W. direction. To begin at the northern edge, the first to be noticed is:—

The Berrington Fault.—This passes north of Berrington, and when it crosses the Berrington Burn W. of Sandyford Bridge, seems to have a large throw—as much perhaps as 500 ft., for it throws the Lickar Coal-measures on the south against beds below the Eelwell on the north. Its direction is not clear, and it must die out rapidly to the eastward if the full throw is at Berrington Mill, for this only throws the Dryburn against the bed above the Lowdean. The throw is down south and it repeats the four upper limestones and brings in the Lickar seams.

Dryburn Colliery Fault.—This seems to have been proved in the workings at New Dryburn Colliery, where the beds are nearly on edge against it. It also throws the Lickar seams against the beds below the Eelwell, so that it must be as large as the preceding, having a throw of 500 ft. down to the south. Its course is north of E.N.E., but it cannot be traced in the drift ground north of Lickar Dean. It repeats the Lickar coals and the four chief limestones.

Lowick High Stead Fault.—This has the same direction as the last. Its throw is down north but is not very large—probably not more than 100 ft. It clearly shifts the Oxford Limestone and the Greenses Coal.

Biteabout Fault.—This inclines more to the north than the preceding. It has been proved at Biteabout, but the throw which is down on the east side is not known exactly. It is probably 300 ft. or more.

Mount Hooly Fault.—This passes near Kyloe Cottage and Mount Hooly, and having a downthrow to the north it may possibly be a continuation of the fault at Lowick High Stead, but having a much increased throw, which is probably 400 to 500 ft., for the Fawcet Coal on the south is about opposite to the Greenses Coal on the north. It is curved in outline, varying in direction from E.N.E. to near N.N.E., and it seems to pass to the west of Beal, but its course there is doubtful.

West Kyloe Fault.—This fault, having a N.E. direction, is inferred from the general strike of the beds. Its throw is down south, probably 150 ft. or so. There seems a break in the crop of the Fenwick Coal, and there is also a gap in the Whin Sill to the westward indicating either a fault or a shift in its position.

East Kyloe Fault.—This also runs to N.E., and was proved in the workings at Fenwick; it was said to be down north 42 ft. so that the Little Coal was opposite the Main Coal.

The Synclinal Fault.—This runs N. and S. from near Lowick Low Stead past Laverock Law and southward. This fault is nowhere seen, nor has it been proved in any way; but in several places, e.g., at Lowick Moor House, there does not seem room for the beds to turn up without a fault throwing down to the west. This also seems to be the case near Holborn Mill and east of Hetton Law. The country is very obscure further to the south and the fault may be dying out in this direction as it appears to do to the northward.

Hetton Coal Law and Kyloe Plantation Fault.—This is one of the longest which has been traced, running right across the area from W. of Wrangham to the coast below Fenham, and it probably passes to the south of Holy Island. Its direction is about N.E. It has a large downthrow to the S.E., say about 500 ft. at Hetton Coal Law, the Fawcet Coal being nearly opposite to the Greenses Coal. Its course across the synclinal is obscure, and the exact line in Kyloe Wood, though the fault must be very large there, is doubtful. It may be a double line of dislocation. At the S. corner of the wood there are old workings in the Fawcet Coal, while close by on the other side of the fault is the base of the Fell Sandstones, so that here there must be a throw down S.E. of 1,000 to 1,200 ft. The sandstone is much crushed here and the dip is abnormal, to the E., and as high as 30°. Further eastward the Howgate and other coals have been worked, and their workings seem to have been stopped by the fault, which apparently has a sharp bend in the Plantation as shown on the Map. The beds are disturbed and the dip is high, west of Fenwick Stead. This is the only large fault that clearly affects the Whin Sill.

The Redsteads Fault has a N.E. direction and throws down to S.E. probably 200 to 250 ft. but it cannot be traced either way.

All the following faults have a general N.E. direction across the strike of the beds but they cannot be traced across the low ground of Hetton Burn and the valley of the Till:—

Cockenheugh Fault.—This is a very large fault south of Cockenheugh and running parallel to that of Kyloe Plantation. It throws down on the south, and brings the Cooper Eye Coal against the base of the Fell Sandstones. The throw is probably about 750 ft. It cannot be traced eastward beyond the south end of Swinhoe Pond, and seems to be older than the intrusion of the Whin Sill.

Dancing Green Hill Fault.—This has a direction like that of the preceding. It passes S.E. of the Ordnance Station Δ 662, and throws down S.E. about 200 ft., the Main Coal and Cooper Eye seams being nearly opposite each other. It seems to be lessening to the eastwards and cannot be traced beyond Dick's Old Walls.

Blagdon Dean Fault.—The general direction of this on Belford Moor is the same as the last, and the downthrow is 300 to 400 ft. in the same direction, the Oxford Limestone on the south being thrown below and west of the Howgate Coal on the north. It bends more towards the south as it goes easterly, and seems older than the Whin Sill; and N. of Lyham Moor, as there is little break in the direct line, the throw probably goes with the branch running west.

Chatton Colliery Fault.—This passes to the north of Chatton Park Hill and turns to the N.N.E. towards Belford Moor. It throws down south about 500 to 600 ft., or nearly the whole thickness of the Fell Sandstones. It cuts off all the coal-workings on Chatton Moor from the Wood End Seam down to the Cooper Eye, none of them having been worked on the north side of the fault for nearly $1\frac{1}{2}$ miles.

Hayhill Burn Fault.—This runs nearly east and west on the S. side of Chatton Park Hill, and has a large throw, probably 600 to 700 ft. down to the north, or the reverse way of most of the preceding. It may range to near Adderstone, but its easterly extension is obscured.

Amersidlaw Fault.—This is not traceable far either way and the amount of throw down N. is uncertain, but may be 200 ft.

Chillingham Fault.—This like the two preceding throws down on the north, and its course is between N.E. and E.N.E. The throw is very large, perhaps nearly 1000 ft., for it is considerably more than the thickness of the Fell Sandstones. The workings in the Blackhill and Main Coals on the N. side abut against the base of the Fell Sandstones on the S. side, and the coals have not been worked to the south. In tracing the fault eastward the throw seems to decrease but its exact position is uncertain. A fault is said to have cut off the coal-workings near Chuck Bridge north of Twizell House.

Ross Castle Fault.—The direction of this is like the last. It runs to the south of Ross Castle Ordnance Station Δ 1036, the highest ground in the Map. Its throw, which is down to the south, must be several hundred feet, but it is more clearly seen in the adjoining area Sheet (109 N.W.), where the Seremerston Coals have been worked to the south of the fault.

Clattery Fault.—This has the same direction as the last, but the throw is down north and the amount uncertain. It seems to cut off the working in the Main Coal at Commonflat, but cannot be traced further; though, as it has the same direction of down-throw as the following, and is nearly in the same line with it, the two may be connected.

Annstead Fault.—That there is a large fault here is manifest, and it has been more than once noticed. The late Mr. G. Tate, of Alnwick, refers to a great fault of 1,000 ft. throw midway

between Islestone and Newton-by-the-Sea,* and Prof. Lebour in 1884 published a paper on a great fault at Annstead in North Northumberland. The fault which is actually seen runs east and west on the foreshore nearly opposite to the farm of Annstead, but there are probably one or more dislocations under the sands at the mouth of the Swinhoe Burn. On the south side of these faults we have the beds below the Oxford Limestone, while on the north side at North Sunderland Snook the highest beds seen are about 50 ft. above the Eelwell Limestone, so that the total downthrow north is 500 to 600 ft.

Quite a series of disturbances on the line of the Annstead Fault have lately (1898) been exposed in the cutting of the new railway from Chathill to Sea Houses, at the Herd's House, near East Fleetham. About 100 yds. north of the house we find a limestone with a steep easterly dip of 40° or 45° , capped by light-coloured calcareous shales. The limestone, which has partings of dark shale, is probably at least 12 to 15 ft. in thickness, and it strikes southward nearly along the line of railway for 40 yds. Here an obscure place is reached where there must be a fault, for south of this we find an entirely different set of beds. On the west side of the line, sandstone about 10 ft. thick overlies 15 ft. of shale, under which comes a limestone 4 ft. with a 6 in. coal below. The whole series dips 50° to the N.N.W., and strikes obliquely across the line, and on the east side we find below the limestone about 20 ft. of shale with a 15 in. coal and underclay at about the middle of it. We now arrive at a fault directed E.N.E. and throwing down to the north, beyond which is a few feet of thin-bedded sandstone overlying a mass of shale, and dipping to the south-west. These rocks are best seen on the west side, and they may be traced for about 20 yds., when they are cut off by another fault parallel to the last and throwing down in the same way. South of this for a short distance we see shales dipping steeply to the N.N.W., but here the section becomes confused, and there is probably another fault just opposite the Herd's House. South of this we come upon greenish micaceous sandstone and shale dipping at first 50° to the south, but the beds quickly assume a more gentle dip and are seen to underlie a white limestone 4 ft. in thickness, which in turn dips under shales and sandstones. It seems probable that the main downthrow north is in the fault opposite the house, and this is in the exact position of the fault drawn on the Map years before this section was exposed.

Swinhoe Fault.—The direction of this fault is nearly W.N.W. and its downthrow is south, probably from 100 to 200 ft. about Swinhoe, but the throw seems to increase rapidly to the south-eastward to as much as 400 ft. or more, and a branch of it or a distinct fault with a downthrow to the north runs eastward apparently near Beadnell Harbour.

* *History of Alnwick*, Vol. 2, p. 464 (1869), and *Proc. Ber. Nat. F. Club*, Vol. vi., p. 203 (1871).

Shoreston Hall Fault.—This fault, which runs east and west on the north side of Sea Houses, is as large or even larger than the Annstead Fault, but with a throw the reverse way, or down to the south. On the north side at the Shoreston Outcrops there are beds considerably below the Oxford Limestone, while at the Tumblers we have beds above the Eelwell Limestone as at the Snook. The total downthrow south must be 600 ft. or more.

Most of the other faults which affect the beds of this area have been described along with the rocks which they affect. Those which are marked on the Map by broken lines are generally uncertain both in direction and in amount of throw, and in the obscure ground near the line of railway, as well as elsewhere there are probably many faults which have escaped detection.

CHAPTER IX.—GLACIAL DEPOSITS.

The Glacial Drift of this area consists of (1) boulder clay of two or three kinds, (2) laminated stoneless clay, (3) gravel and sand, which generally assumes the form of irregular mounds, and (4) a set of mounds of sand and gravel which take a linear form—straight or curved—and go by the name of Kaims. The Glacial Drift, as will be seen by reference to the map showing the Superficial Geology, is pretty generally distributed over the whole area, with the exception of the two parallel tracts of high ground, the one formed by the Fell Sandstones, the other by the Whin Sill.

Boulder Clay.—In the interior this is of the usual character, a pretty stiff bluish or grey clay, interspersed with many glaciated boulders of various kinds, but over the low ground bordering the coast there is a red or reddish clay with comparatively few stones, and those mostly small. This red clay seems to be of later date than the blue clay, and to overlie it where the two occur together.

The drift is very variable in thickness. In one of the best sections, the banks of The Low, east of Lowick, there seems to be at least 30 to 40 ft. of stiff blue clay. At the new sinking at Lickar Lea there was 12 ft. of clay, and in a pit near New Dryburn, 36 ft. In the Brownrigg borings it varied between 4 ft. 6 in. and 11 ft. Further south about 10 ft. of boulder clay of the usual character may be seen at the east end of Hetton Quarry, and it was 24 ft. thick in a boring at the west end of Wrangham Moss, west of Redsteads. The drift must be very thick in the bands of the Wooler Water south of Wooler, where it seems to be as much as 170 ft., but the greater part of this thickness is gravel and sand. In the lowlying part of the valley of the Till about Chillingham Barns there is a reddish clay with few small stones. Perhaps this is connected with the stoneless clay of Chatton Tile Works.

There is said to have been good clay, not stony, at the old Tile Works near Chillingham Barns, and there was an old clay pit, now a pond, north of the village of Chillingham. In the west bank of the Till, nearly opposite Chillingham Barns, is the following section:—

	Ft. In.
Clay, brownish and sandy, with a few small stones, more sandy below	6 0
Gravel	1 6 to 1 9
Clay, darker, sandy, laminated in places, dries to a reddish-brown, seen for several feet.	

In the eastern bank of the river, opposite Broomhouse, is seen:—

	Ft.
Clay, reddish above, with thin gravel seams	8 to 10
Clay, chocolate-coloured below, with a few stones	7 to 8

The Chatton Tile Works are in a kind of stoneless clay, in part slightly laminated with loam, and this kind of clay seems to rise to a height of about 50 ft. above the river, and in places to form a kind of plateau. Traces of it are seen in several localities further down the Till, and it may possibly have the same origin as the grey stoneless clay of Milfield Plain in Sheet 110 S.W.

The relation of the red clay of the coast to the older boulder clay is well shown in several sections on Holy Island, and it will be seen that often a band of gravel is interposed between the two kinds of clay.

The following section exposed in the cliff at Tripping Chare End, west of the village, illustrates this point:—

	Ft.
Dark soil -	2 to 3
Red clay, with few stones -	8 to 9
Angular gravel, 2 ft. (ten yards farther north)	3
Dark grey stony clay (at north end of section).	
Dark shale, with ironstone.	

On the eastern side of the island at Red Brae, north-east of the Lough Farm, there is a good section:—

Boulder clay, reddish and with few stones	About 20 ft.
Boulder clay, dark grey, with many well-scratched stones	
Shale.	

Here there is no gravel between the two clays; but a little further north, and just south of Emmanuel Head, there is a very instructive section about 60 yds. in length:—

South End.	Middle.	North End.
Red clay, with a few small boulders, 0 to 3 ft.	Red clay, with few stones, 6 to 7 ft.	Red clay, with few stones, a few ft.
Gravel, rather coarse and not well stratified, with a wedge of sand.	Coarse gravel, with a little sand, 6 ft.	Sand with coarse gravel, 7 to 8 ft.
Sandy shale and thin sandstone.	Dark grey, slightly purplish, stiff boulder clay, with many well-scratched stones, 5 to 6 ft.	Stiff boulder clay, as in middle part, seen for 2 to 3 ft.

Throughout the gravel and sand are found a good many fragments of coal, and these in one or two places form layers 2 to 3 inches thick at the top of the gravel.

The cliff-sections on the west side of the Fenham Flats seem all to be in the upper red clay, but none of them are very good. Both clays were seen at the Mount Hooey Tile Works, south of Beal. The red clay, which was worked, is about 12 ft. thick, and it rests on a blue stony clay containing many scratched limestone blocks.

The red clay seems to be spread over much of the low-lying country bordering the coast up to a height of 125 to 150 ft. above

the sea, and even to over 200 ft. west of Newham. In the north, about New Haggerston, it appears to cover a pretty wide area, while further south it is a narrow band, mostly east of the main north end. The largest area it occupies is in the southern part of the district, where it probably is the clay found at the surface over most of the ground that lies east of a line from Bainburgh to Preston. In the borings near Elwick (see *Appendix*, p. 134), the clay varied from 8 ft. to 35 ft. in thickness; in one of them a bed 32 ft. thick, being described as "clay with boulders." At Ross a boring proved 30 ft. of clay. In the Fleetham borings the clay was only from 5 ft. to 7 ft. 6 in. thick. In a boring by the roadside a little north of Hoppen, the clay was 40 ft. thick, and a well at Hoppen is said to be 60 ft. deep in clay. At the west end of the Coldrife Colliery workings, the drift must be 100 ft. thick or more, for at about the depth of 100 ft. the coals were cut off by sand. A pit to the eastward was sunk through 60 ft. of clay and sand. At Lucker Station there was proved:—

	Ft.	In.
Clay	9	3
Loam and sand	4	2
	—	—
	13	5

The Chathill Claypit gives a section of the clay. The part worked is reddish-brown in colour, and nearly free from stones, but not laminated; it is rather sandy and bluish below in places, and its greatest thickness is five feet. Below is a strong clay said to contain lime, which is not worked.

The cuttings on the new railway from Chathill to Sea Houses afford some interesting sections in drift. The greatest thickness exposed seems to be east of Pasturehill, where from 15 to 18 ft. of stiff bluish clay with many glaciated stones may be seen. This cutting exposes no rock. Another section in drift may be observed in the cutting nearly 400 ft. long close to Chathill Station, and here again no solid rock is seen though the cutting is about 15 ft. deep. The lowest bed here is a stony clay like that of the Pasturehill cutting, but the section is not so good. Overlying this boulder clay through the greater part of the cutting, and especially well seen on the south side, is a greyish laminated stoneless clay, sharply marked off from the stony clay, and decidedly unconformable to it, for it lies in basins or hollows of the boulder clay on a very uneven surface. The boundary-line between the two sometimes sinks nearly to the level of the rails, and in others rises to the surface of the ground, so that as we walk along the line we find the section of the laminated clay makes a series of festoons. Apparently overlying this clay in places there is a reddish non-laminated clay nearly free from stones. The laminated clay may also be seen in the cutting near Fleetham, and here it apparently lies directly on solid rock without the interposition of any boulder clay.

Sand and Gravel.—The patches of these are very numerous and cannot be described in detail. They are shown on the

Drift Map by a pink tint. Some of them may correspond to the beds of sand and gravel which we have seen in some cases to separate the red clay from the blue clay; but the majority of them are probably different, some being newer than the red clay, while others are intercalations in the blue clay. The greater extent is in the south-west, in the area west of the Till and up the valley of Hetton Burn; but sections are not very numerous. At Broomhouse, south-west of Chatton, a boring for water proved 30 ft. of sand, and a little to the eastward a drain at the road 12 ft. deep was in sand. On the west side of the Wooler Water above Haugh Head, 30 ft. to 35 ft. of gravel can be seen in the bank. The lower part, about 20 ft. thick, is rather coarse, and there is no indication of bedding, while the upper part is a somewhat finer gravel, and there is a loamy wash above in places. Half a mile farther down the stream, in the left bank, 10 ft. to 12 ft. of dirty gravel, the lower part clayey, overlies 15 ft. to 20 ft. of stratified sand; and gravel overlies sand in several places. About 200 yards south of Bridge End, Wooler, the west bank of the stream, which is 170 ft. high, appears to be composed entirely of drift, and most of it seems to be gravel or sand, though there appears to be a mixture of loamy clay and dirty gravel for about 25 ft. up from the bottom.

North of the Till there is a good deal of sand and loam which does not always or perhaps generally take the characteristic mouldy form, and as the Carboniferous sandstone is soft and decomposes readily in places, and the ordinary boulder clay is sandy, it is difficult without clear sections to distinguish between the modern sandy wash from the hills, the true Glacial sand and the sandy boulder clay. Generally the pits that have been opened in sand and gravel are small, and little is now to be seen in them. Between Fenham and Fenwickstead, however, there is a large pit, out of which much gravel was got for ballast on the railway, and it is said that there was formerly a large mound here which has been carried away.

Kaims.—There will be noticed under this head the marked set of sand and gravel mounds which runs in a fairly straight line from Spindleston to Preston, a distance of $5\frac{1}{2}$ miles, as it is possibly of later date than all the drift previously described. It commences at the roadside east of Spindleston in the form of a low, narrow, gravelly or shingly ridge, with a mossy hollow on each side of it. A little to the southward it is banked up against the rising ground to the east, and here it gets the name of Long Barracks. Before reaching the road that runs east from Bradford it is again detached and stands up as a marked and high ridge above the series of mossy hollows on either side, which must at one time have been small lochs.* It is here called Welt Hill, while south of Golden Hill it gets the name of Bradford Kaims and becomes less straight, having indeed quite a wavy or snaky outline. It is in places only 30 yds. in width,

* Some notice of these Kaims will be found in the late Sir A. C. Ramsay's *Physical Geology of Great Britain*, 5th Ed., 1878, p. 386.

but is more usually about 40 yds. and even more. It ends rather abruptly, but Pigdon Hill, N.E. of Hoppen, where the camp is, seems a portion of it detached, or connected with it by only a very low ridge. There are few and poor sections, but the mass seems to consist of coarse gravel and shingle, earthy or dirty generally, with some sand. We may consider that the Kaim proper ends at the north side of the bog, east of Hoppen, so that it has a length of only about two miles; but the line of banks and detached mounds to the southwards, though not so markedly Kaim-like in aspect, seems evidently connected with it, the ridge of the Kaim itself being lower and broken where it is crossed by the roads. South of the bog there are a good many gravel pits at Ell Hill, one of which showed:—

- Dirty clayey gravel.
- Fine gravel and sand, irregular.
- Coarse gravel.

A broadish ridge continues southwards to Newham, with a steep bank on the west side, where is Newham Lough. This ridge seems mainly to be sand, but on arriving at Newham we find a great thickness of gravel, 24 ft. having been proved in a well; and the low ridge called Crutch Hill between the two bogs to the southward must have been remarkably Kaim-like before the railway was made, it having been a high and steep ridge before being dug for ballast. There is a gravel pit in the village in which appeared 6 ft. of brown sand mixed with fine gravel. This contained lenticular seams of broken and drifted coal fragments, one of which was 2 yds. long and 4 ins. thick. The broken line of Kaims is continued by Horse Hill and the remarkably entrenched or artificially terraced Chat Hill, along the east side of Long Nanny to Preston, on the west side of which there is an old sand pit 20 to 30 ft. deep, which shows some light brown sand, and there seems to be a trace of clay above on the east side.*

Glacial Striae on Rock Surfaces.—The visible glacial striae on rocks in this area are almost entirely confined to sandstone and basalt. No doubt there were a good many visible on the limestones at one time, but in most cases they have disappeared from the effects of weathering or from the rock having been quarried away, the limestone being almost always quarried to the dip, so that there is now a thick covering of shale on the top of the quarry.

As a general rule the direction of ice-movement, indicated by the striae, was between due E. and E.S.E. in the northern part of the area, as is seen by glacial markings about Kyloe and Bogle Houses, and also by those south of Buckton and S.W. of Detchant. Along the western edge of the area striae are few; there is one set—towards E.S.E.—E. of Doddington, and another further north near Hetton Coal Law, where the direction is

* In *Trans. Ber. Nat. F. Club*, Vol. v. (1865), p. 239, Mr. G. Tate records having found a few glaciated rocks among the water-worn gravels and sands of which these kaims are composed.

towards S.E. The ice in its progress eastwards seems to have trended still more in a southerly direction, so that about Middleton and Belford we find numerous striae on the whin with a general S.E. direction, and others still further eastward between Belford and Bamburgh, where the direction tends to become nearer S. than E. On the Farne are striae trending E.S.E., but further eastward on Staples Island and the Brownsman there are numerous striae trending from 30° to 35° E. of S., besides many deep and wide grooves or ruts running in the same direction, which may be glacial, but may possibly have another origin, as this is the general direction also of the numerous joints in the whin. These deep ruts were also noticed south of the Longstone, and also on Little Scarcar. One of these at the south end of Staples Island was about a foot broad and 3 inches deep. This island and the Brownsman also have patches of glacial clay which must be in places 10 to 12 ft. thick. The clay is reddish and contains boulders of Silurian greywackes, porphyrites, and Carboniferous sandstones. There is some clay also on the Farne and on West Wideopen. In the S.W. part of the area there are a good many striae on Weetwood Moor running nearly due S. or S.S.E. with few exceptions.

East of the Till the direction of the striae is generally very different, as is seen on Lyham Moor and in three places east of Chatton where the trend is between E. and E.S.E. But to this there is opposed the anomalies N.E. of Chillingham where on the same rock are two sets of striae, one trending 15° W. of S., the other 20° E. of S. The direction near Belshill and west of Ellingham is about S.E. The late Mr. G. Tate, of Alnwick, who noticed glacial striae at Middleton, north of Belford,* and on the Farnes, also described striae on the limestone at Swinhoe, but these I did not see. He says "At Swinhoe the limestone, which is also below the boulder clay, is similarly polished and striated in the direction of north 50° east to south 50° west."† The limestone (now quarried away) at the caves in the north of Holy Island is said to have been glaciated.

Distribution of Boulders.—The distribution of boulders in the drift and on the surface is another proof of the direction of the ice-movement. The most numerous and widely distributed erratics are those which have come from the westward down the valley of the Tweed, viz. of Silurian greywackes, porphyrites and quartz. To the southward, and S.E. of the outcrop of the Whin Sill, boulders of this rock are very common. In many places very few erratics are seen and the drift seems to consist mainly of local rocks; but perhaps this is due to the thinness of the drift, for the erratics are probably the remains of drift which has been carried away by subaerial agencies. The boulders are generally small on the eastern side of the area, and I know of none very large visible anywhere. The largest erratic I remember to have

* The polishing and striation on the limestone at Middleton is first noticed in *Proc. Ber. Nat. F. Club*, Vol. v., 1864, pp. 95 and 96.

† *Proc. Ber. Nat. F. Club*, Vol. v., p. 237.

seen is one of porphyrite, which is found at Fowberry Tower; it is about 5 ft. by 5 ft., and was brought from Heatherly Hall. There is another on Chatton Park Hill, 300 yds. east of the summit which measures 3 ft. by 1½ ft. Large Whin boulders were got out near Sionside, west of Belford, and one at Adderstone Mains was so large that a hole was dug and it was buried. West of the Kyloe Hills and north of Lowick Forest, besides boulders of greywacke, porphyrite, and quartz, some of the peculiar chert from Carham, on the Tweed, were noticed. On Whitsunbank Hill, and to the east of Trickley, some small boulders of a peculiar fine yellow sandstone were seen. To the north-east of Chillingham there occur in several places boulders of granite which seem to have come from the Cheviot granite area, but perhaps not in a direct line. A broken one at Amersidelaw Farm measured 4 ft. 3 in. by 2 ft. 6 in., and another broken one, half a mile to the E.S.E., was 3 ft. 6 in. long. There is another block of granite in Sandybank Plantation, about three-quarters of a mile E.N.E. from Chillingham Castle, and one about 2 ft. in diameter by the roadside at Whinny Hill, half a mile S.E. of Coal Houses, between which and the summit of Whinny Hill, Δ 621, is a large pink porphyrite boulder.

CHAPTER X.—POST-GLACIAL AND RECENT DEPOSITS.

Fresh-water Alluvia.—With the exception of the alluvium of the River Till and of the Wooler Water, the principal patches of alluvial matter lie in bogs, which were probably at one time lakes or marshes. These have, however, nearly all been drained either naturally or artificially. The shrunken lakes or lochs still remain at Embleton's Bog, near Lucker, called Newham Lough, and at Coldmartin Lochs on the high ground east of Wooler. The bogs are especially numerous along and near the line of kaims from Spindleston southwards to Preston. They have generally a basis of clay, silt or sand, but most of them have in addition a growth of peat on them, sometimes of great thickness. Occasionally we meet with a deposit of shell marl. This has been noticed at Embleton's Bog, and a deposit of this nature has been described by Mr. James Mitchell* as occurring in a bog about 1½ miles from Wooler, on the estate of Middleton Hall. Mr. Geo. Tate† gives a further description of it, and we learn that this is known to have been a lake. It covers about 4 acres and is situated on the west side of the Wooler Water opposite Haugh Head. The following is given as a section of the deposit :—

Peat, 2 to 4 ft. thick, containing prostrate trees of Oak, Willow, Hazel and Birch, and also Hazel nuts and acorns.
 Marl, 8 to 10 ft., in which have been found skeletons of the Red Deer,‡ teeth of the Boar, and great numbers of fresh-water shells.
 Blue Clay, a few inches.
 Boulder Clay and gravel.

The shells forming the marl include *Sphaerium*, *Succinea*, *Planorbis*, *Limnea*, and *Valvata*. This is called Creswell Bog on the six-inch map. In the Transactions of the same Club§ Mr. P. J. Selby gave a description of some remains of *Bos primigenius* found many years previously in cutting a deep drain in a low flat district known by the name of the Adderston Mains Bog, through a portion of which the railway runs to the north of Lucker Station. The upper stratum of the flat consists of a thick deposit of peaty earth, which, at that time, in some of the wettest parts, was overgrown with willows, aquatic plants and reeds. Beneath this is a deposit of whitish clay, gravel, and water-worn stones in which—but not deeply embedded—the bones were found. There are some rather large bogs, or “mosses” as they are called, in the neighbourhood of Lowick and Holburn, covered with thick growths of peat, e.g., Moss Plantation; Kemping Moss, south-west of Lowick; and the Holburn Colliery Bog, east of Holburn.

* See *Proc. Ber. Nat. Field Club*, Vol. i., 1834, p. 41.

† *Ibid.*, Vol. iv., p. 158.

‡ See “The Red Deer in Northumberland,” by G. P. Hughes, *Geol. Mag.*, 1898, p. 119.

§ Vol. iii., 1850, p. 45.

The numerous narrow strips of sand and gravel along the sides of the small streams do not call for any special notice. The alluvium of the River Till is composed mainly of silt, loam, and sand, with an occasional higher terrace in which some gravel occurs. The alluvium of the Wooler Water, a swifter running stream, is mainly gravel and sand, the material becoming finer near its junction with the Till. There is a marked terrace of gravel, connected with both streams, at West Weetwood. The higher river-terrace opposite Doddington is composed of sand and fine gravel. The lowest flat, or ordinary alluvium below the junction of the two rivers is only about 120 ft. above the sea and is part of the extensive flat called Milfield Plain described in the *Explanation of Sheet 110 S.W.*

There is an extensive low-lying alluvial flat about Brockmill, north of Beal, and there are others of the same kind, but not so large, at Ross, Annstead, and near Newton-by-the-Sea. They are composed of silt and sand, and are probably all of an estuarine nature, partly fresh-water and partly marine. They are all only a few feet above the present high-water mark of spring tides, and are separated from the present coast-line by hills of blown sand, so that in comparatively recent times they were probably covered by the sea. The most striking of these is the one at Brockmill, much of which is only from 10 to 13 ft. above the Ordnance Datum, and as this is along the Northumberland coast some 8 ft. or so below high-water mark, the Brockmill flat is only 2 to 5 ft. above the sea-level. But in all these cases the streams seem to have recently flooded the old marine flats and covered them with a more modern fresh-water deposit of silt, etc.

Marine Alluvium, Raised Beaches, &c.—The retreat of the tides lays bare an extent of several square miles of recent marine alluvium in the northern part of this area about Holy Island. The northern portion of this consists of pretty firm sand, but the southern part, called Fenham Flats, is mainly silt and mud. To the south of this and west of Ross Links is a low raised beach of considerable extent, about 5 or 6 ft. at most above high tide mark, composed of silt and grey clay, with traces of marine shells, and having a border of shelly sand along the coast. Northward from this place narrow raised beaches of sand, loam, and gravel are found occasionally up to Beal Point, with larger and more marked areas at the mouths of small streams. None of them seem more than about 14 ft. above Ordnance Datum, or 6 ft. above high-water mark. The alluvium of Brockmill, as before mentioned, is but an extension westward of the marine flat, only separated from it by the narrow strip of blown sand at the coast, and even now at very high tides the sea-water comes up the stream so as nearly to make an island of Beal. South of Ross again is a great extent of silt and clay of an estuarine character, a continuation of the modern marine deposit of Chesterhill Slakes;* but south of Budle Bay almost the only

* Misprinted "Stakes" on the one-inch Map.

examples are those at Annstead and Newton-by-the-Sea, where the deltas of the present streams are only separated from the sea by ridges of sand hills. However, there may be other tracts of this kind along the coast, now covered by blown sand. We find such about The Old Law, north of Ross Links.

But by far the most perfect examples of raised sea beaches in this area are to be found skirting the coast of Holy Island. There are two examples in the northern part of this island west of Caves Haven, of beaches partly covered by blown sand, and a marked gravel beach about 8 to 10 ft. above high water mark occurs on the east side of the island opposite Sheldrake Pool. These, however, are but narrow. Those along the southern part of the island are broader and larger, and east of the castle there are two distinct levels of gravel, the highest of which is probably about as high as the one at Sheldrake Pool. Beaches may also be seen on the west side of the island, but they are only narrow strips, and patches at two levels occur in numerous places in the Snook—the highest being gravel and shingle. The late Dr. Johnston of Berwick-on-Tweed, who spent some time on the island in May, 1854, gives the following account* of some raised beaches which he examined. “We soon got to the shore opposite St. Cuthbert’s Isle, where his beads were sought for, and we gathered a few specimens. . . . There is a deposit of shells in the bank here at a considerable elevation above the present level of the sea—probably not less than 12 feet. The shells are of the commonest kinds. The common mussel (*Mytilus edulis*) in two varieties composes most part of the deposit; and we find intermingled *Littorina littorea*, *Patella vulgata*, *Cardium edule*, and a few broken valves of the oyster. In some of the mussels I found small pearly concretions, and on the external surface the basis of *Corallina officinalis*, *Balanus communis*, *Serpula tricquetra*, and *Membranipora membranacea*. . . .”

“We started for a walk. This began at the entrance to the Island from the mainland, and we pursued the line of shore northwards. . . . We came in a short time to a sort of creek leading inland, formed by a removal of the links or sands which had once lain above the present surface, which is a bed of gravel thickly mixed with dead and bleached shells of *Helix aspersa* and *Helix hortensis*, but more especially with *Cardium edule*. With these there were shells of *Tellina solidula*, *Tellina carnea*, *Littorina littorea*, *Purpura lapillus*, *Patella vulgata* and *laevis*, *Helix nemoralis*, and some minute shells whose names could not be accurately ascertained.” . . . “To-day our exploratory ramble began at the limekiln on the links where it terminated yesterday, and we resolved to make a circuit of the north end of the island. It is a barren link everywhere—a confused and intricate succession of sandditches, hills and hummocks, amidst which are excavated by the variable winds, deep bowls, creeks, little bays, and comparatively extensive level plateaus. The creeks in general are bare, with the sandy

* *Pro. Ber. Nat. Field Club*, 1873, pp. 30, 35

surface thickly strewn with land and marine shells; but of some the surface is covered with small gravel in which there are few shells."

At the time when the highest beaches were formed Holy Island must have been a group of three or more separate islands. The castle was a detached rocky islet, and the eastern part of the island was separate from the western, the sea filling the valley or hollow that runs northward from The Ouse, east of the village.

Blown Sand.—This covers a good deal of Holy Island and forms a great part of the coast-line to the southward, the hills having generally the name of "links." Its greatest extent is at Ross Links, where it covers an area two miles long by half a mile broad, and where may be seen several of its characteristic horse-shoe shaped hollows. Towards the south end of this tract it has been arranged in the form of marked ridges and furrows running in a N.N.W. direction, and nearly parallel to the coast line. The highest hills here are 65 ft. above the sea. On the Snook of Holy Island, the sand forms hills of 30 ft. or 40 ft. in height, which seem in places to be founded on shingle ridges. On the main part of the Island it lies in many places over rock or boulder clay. South of Budle Point and at Bamburgh Castle there is blown sand considerably above the 100 ft. line, but it here rests on rock and drift. From the Harkess Rocks, north of Bamburgh, the links stretch continuously to Shoreston Hall, a distance of three miles, and near Greenhill attain their highest point, viz., 87 ft. There is another stretch of sand about Annstead, and a still longer one from Benthall to Newton-by-the-Sea following the curve of Beadnell Bay, many of the hills being 50 ft. in height. There are occasionally many fragments of marine shells in the sand as at Old Law, south of Holy Island. There are small patches of blown sand on the island called West Wideopen, immediately east of the Farne Island. Near Budle Point, the Whin Sill is finely polished and fluted by "sand blasts," or blown sand set in motion by the wind. The flutings run east and west, roughly parallel to the direction of the coast here.

CHAPTER XI.—ECONOMIC GEOLOGY.

ORES AND MINERALS.

Iron and Lead Ores.—The occurrence of these ores was recorded as far back as 1814 by Winch, who says, “Strings of ore (lead) have also been discovered on the coast of Northumberland at Ellwick, nearly opposite to Holy Island, and on the eastern side of the island itself.”* He goes on to say: “The Carron Company formerly collected on Holy Island a part of the [iron] ore smelted at their furnaces, but they have long since relinquished this undertaking.”†

Fine large pieces of galena were found north of the Coal Burn and west of the road leading from Hetton Coal Houses to Lowick, about the point where a fault is marked crossing the Woodend Limestone in an E.N.E. direction. At the south end of Staples Island (the Farnes), and in the Whin Sill, there is a small vein of galena trending N. 32° W., and there is also a vein of galena at Beadnell on the foreshore to the north of the whin dyke there and between Limestones No. 3 and 4, from which lead ore is said to have been got. It runs nearly due north.

The only ironstone worth notice is that which occurs in large nodules in the shale above the Acre Limestone. This is what is referred to above by Winch; and J. Scape, in his articles on the geology of Holy Island in Raine’s “North Durham,”‡ states that the ironstone on the west side of the island near St. Cuthbert’s was used by the Carron Company. The section is immediately south of Tripping Chare End to the west of the village, and the same shale with ironstone nodules is very well seen in the bay called the Caves Haven, at the north end of the island, and also above the limestone in the Dun Quarry near Lowick.

There is an old slag-heap or bloomery on the north side of Rosebrough Moor, S.W., of Warenford. It is at a place called Hot Law, a prominent knoll 600 ft. above the sea on the south side of the long plantation and just east of the foot-track that crosses the moor from N.W. to S.E.

Coal.—The number of poor seams of coal worked in this area amounts to about 25, and of course there are many thin seams that have never been worked at all. The only pits being worked at the time the Survey was in progress were those at Biteabout Colliery, at Brownrigg, to the south of Lowick, and at the Chatton

* *Trans. Geol. Soc.*, Ser. 1, Vol. iv., p. 81.

† *Ibid.*, p. 67.

‡ pp. 168—173.

Colliery, near Redhouses, between Chatton and Belford. Many of the seams are only fit for use in lime-burning, and they were extensively mined for that purpose in the 18th century. As will be seen from the sections given, most of the seams that are thick enough to be workable are seldom pure, they are generally much split up by bands of stone or shale, which in places thicken to such an extent as to render the seams worthless. I know of very few instances where coals of 1 ft. in thickness have been worked, but several varying from 1 ft. 3 in. to 1 ft. 6 in. have been worked in places; they generally run, however, between 2 ft. and 3 ft. One at Beadnell is said to have been 6 ft. thick for some distance, but poor in quality. The coals are mostly free-burning and not highly bituminous. They are not gassy coals, and do not give off carburetted hydrogen, so that naked lights are used in all the pits.

In many cases the old workings were unwatered, where possible, by means of levels, carried up from lower ground, examples of which may be seen in Mount Hooly Dean, at Coalburn, Warenton Dean, and on the south side of Kemping Moss. All the pits are comparatively shallow. The deeper are: Lickar, 32 fathoms, and Dryburn 34 fathoms to the Lickar Main Coal; Biteabout, 32 fathoms; Wrangham, 30 fathoms; and one near Hetton Coal Houses, 25 fathoms, to the Fawcet Seam; and Chatton, 25 fathoms to the Cooper Eye Seam.

The mode of working the coal is by the "long wall" system, the band being utilised in making pillars to support the roof; and in some cases where the roof is a soft one, a portion of the seam has often to be left for the roof, and timbering has to be resorted to.

Building Material.—There is abundance of good sandstone for building-material, and quarries have been opened in many places in good freestone. One of the largest is west of Twizell House in Quarry Plantation, the section of which shows massive white sandstone, many feet thick, largely quarried during the making of the railway, for bridges, &c. This quarry is in a sandstone which belongs to the upper part of the Scremerton Coal Series, and several other quarries of good stone are on about this horizon, e.g., Rogues Road quarry, west of Belford Race Course; Colour Heugh Quarry,* west of the Kyloe Hills, which is in a massive whitish sandstone 30 to 40 ft. thick; Fine Hill Quarry, west of Kyloe Wood, the stone of which is massive, rather fine, and whitish and yellowish in colour. There are also many quarries in the rather coarse and generally massive Fell Sandstones, brownish-white or reddish in colour, of which I will only mention that of Chillingham Newtown, west of the Till, which has fine sandstone below in which *Archelonodon* (*Anodontia*) *Jukesi* was found. The quarries at Beal and Fenham, and some further south, near the railway, are in the Limestone Series.

* This quarry has lately (1898) been much enlarged, the stone having been used for the rebuilding of Haggerston Castle.

The stone of which Holy Island Priory was built is said to have been quarried on the beach at Cheswick, and carted across the sands to the island.

Road Stone.—Basalt both from the Whin Sill and the Whin Dykes is extensively quarried for road-metal. In the Whin Sill are large quarries north of Belford, and at the northern extremity of its range west of Kyloe; and there are quarries about Kentstone and Mount Hooly in all the dykes, and also in the one in Lickar Dean.

The Dun Limestone was very much quarried for road-metal on Chatton Moor at Linkey Law, near the Red Houses, the quarry being half-a-mile long.

Lime.—All the principal limestones have been largely quarried and burnt for lime in the neighbourhood of Lowick, especially the Dryburn and the Eelwell; at Bowsden the Acre and the Eelwell have been worked. The Woodend has been much quarried at Barmoor Red House and near Hetton Coal Houses, and also on Chatton Moor and at Belshill. The Oxford has been quarried at Low Lynn and the Eelwell at North Sunderland and Beadnell. At Lowick this latter limestone has been worked under 25 to 30 ft. of "cover," principally shales. The following analysis of the Hoppen Limestone was made by Dr. Stevenson Macadam of Edinburgh, at the instance of the East of Berwickshire Agricultural Association:—

Analysis of Hoppen Limestone.

Lime	89·86
Magnesia	1·34
Oxide of iron	3·16
Alumina	0·74
Phosphoric acid	0·42
Siliceous matter	0·56
Water of combination and carbonic acid	3·92
	—
	100·00

The following analyses of Mountain Limestone from this district are by Mr. Hugh Taylor:—*

	North Sunderland.	Holy Island.	Holy Island, Bottom Bed.
Carbonate of lime	96·637	59·280	96·234
Carbonate of magnesia	1·938	35·121	2·076
Peroxide of iron and alumina.	0·526	3·746	0·242
Sand	0·707	1·384	1·273
	99·808	99·531	99·825

* *Trans. N. of Eng. Inst. Min. Eng.*, Vol. iii., p. 24. See also Greenwell's "Mining Engineering," p. 79.

Oil Shale.—There are three bands of oil shale, sometimes called parrot coal, on different horizons. The lowest is in the Scremerston Coal Series, but apparently above the Blackhill seam or about its horizon. The best known and most constant occurs however between the Woodend and Oxford Limestones, among the Howgate Coals, and specimens of it may be seen in the old pit-heaps to the S.W. of Belford Moor and Newlands West Lodge. It seems of good quality but is probably thin.* A third band associated with the Lickar Seams, but apparently above all of them, being nearly the highest beds seen in this area, was noticed in the Berrington Burn, to the east of Sandyford Bridge.

Sand and Gravel.—Sand for building-purposes and gravel for roads and walks have been dug in a good many places. The principal of these have been already mentioned. Mr. E. J. Garwood mentions that the sand (decomposed rock) from the eastern side of Cockenheugh was formerly used, mixed with grease, for sharpening scythes, &c.

Clay.—Both the blue and the red boulder clays seem to have been dug principally for making tiles (roofing and draining tiles), as there is no lack of stone in the district for building-purposes, and bricks are not required. For notice of the pits at Chatton, Chillingham, Chathill, and Mount Hooly, I must refer the reader to Chapter IX. on the Glacial Deposits.

At Bar Moor the clay (which seems the ordinary blue clay) was thin and patchy, and only 3 ft. to 5 ft. thick. The section in the pit at Belford Station is a poor one; the clay does not seem very stony, and may be part of the red clay. At the Middleton Tile Works, Detchant, they seem to have used the ordinary blue clay. At Newham Tile Works, Newham Newhouses, clay was worked to a depth of 6 ft. (probably the red clay), and is said to have contained small limestones boulders. At the pit in a hollow east of Beal a stoneless clay was worked which seems to have been deposited in an old loch.

SOILS AND AGRICULTURE.

Owing to the general wide covering of drift, the nature of the soil has comparatively little to do with the outcrops of rock of different kinds. The sandstone hills are mostly barren and covered with heath, as are also some of the hills formed by the outcrop of the Whin Sill, though the latter where decomposed gives a fairly fertile soil. The Map showing the Superficial Geology will indicate where light or heavy soils abound according to the distribution of the drift sands and clays. Liming was formerly much resorted to, hence the abundance and size of the old limestone quarries, and the opening of pits in poor seams of coal, not now worth working.

* This band is noticed by Mr. Tate.

WATER SUPPLY.

Potable Water.—The supply of water is often obtained from streams, springs, and natural wells; and from the abundance of limestone in the rocks and drift it is generally "hard," except where it is obtained from the Fell Sandstones. Dod Well, Doddington, is a noted spring of soft water coming from the sandstones,* and there are two or three good springs on Holy Island.

Of artificial wells the most noted is the old one at Bamburgh Castle, 150 ft. deep, which goes down through the Whin 75 ft. into the sandstone below. Sandstone, or the sand below the boulder clay, is the most common source of the water of the wells. A well sunk at the Coastguard Station on Holy Island went through 8 ft. of soil and clay and 28 ft. of sandstone. At Ross a well 13 ft. deep was sunk, the upper half in stoneless clay and the lower part in quicksand. Many of the wells are very shallow.

Mineral Wells.—There is one of these at Harkess Rocks, north of Bamburgh. A chalybeate spring occurs near the junction of two streams N.E. of Lowick Moor House; and one called the Black Well is situated S. of New Haggerston, the water of which comes from a boring.

* In Vol. vi., p. 147, *Proc. Ber. Nat. F. Club* it is said to yield 72 gallons of water per minute at a temperature of 47° F., and Cuddy's Well yields 20 gallons per minute.

A P P E N D I X.

I.—LISTS OF FOSSILS.

A.—FOSSILS FROM THE LOWER CARBONIFEROUS ROCKS
COLLECTED BY THE GEOLOGICAL SURVEY.

Named by MR. G. SHARMAN and MR. E. T. NEWTON.

The following is a list of the localities in the area of Sheet 110 S.E. from which specimens have been obtained by the Geological Survey, the numbers corresponding with those appended to the names of the species :—

1. Chatton Limestone Quarry, $2\frac{1}{2}$ miles N.E. of Chatton.
2. Linkeylaw Limestone Quarry, S.W. of preceding, on Chatton Moor.
3. Chatton Lime Works, Pit Heap, ($\frac{1}{4}$ mile N.E. of).
4. Blackhill Coal Seam, near Linkeylaw Quarry (W. of).
5. Amersidelaw Moor, Old Coal Workings, $\frac{1}{2}$ mile S. of Coalhouses.
6. Twizell South Dean, West of Warenford.
7. Lucke Limestone Quarry, $\frac{1}{2}$ mile W. of Lucke.
8. Bell's Hill Quarry, E. of Mousen.
9. Hoppen Quarry, $\frac{1}{4}$ mile N.E. of Lucke Station.
10. Burton Quarry, $\frac{1}{4}$ mile S. of Burton Farmhouse.
11. Glororum Quarry, $\frac{1}{4}$ mile E. of Glororum Farmhouse.
12. Glororum Sandstone Quarry, $\frac{1}{2}$ mile S.W. of house.
13. Chesterhill Dean, W. of Waren Mill.
14. Budle, Shore Section, W. of (Chesterhill Slakes).
15. Budle, N. of, Shore Section, W. of Heatherhouse.
16. Farne Islands, the Bridges, E. of the Kettle.
17. Farne Islands, the Brownsman, Hollow S.W. of house.
18. Holy Island, Shore 200 yards S. of Cathedral Ruins.
19. Holy Island, Limestone Quarry, S. of Caves Haven and $1\frac{1}{4}$ miles N.N.W. of Castle.
20. Holy Island, No. 3 Limestone, W. of Caves Haven.
21. Holy Island, Shore Section at Castle.
22. Easington Limestone Quarry, $\frac{1}{4}$ mile W. of Easington Demesne.
23. Easington Grange Mill, Quarries S. of Elwick.
24. Kentstones Quarry, between Lowlynn and Kyloe Cottage.
25. Beal Point, Shore Section, one mile E.N.E. of Beal.
26. Cockenheugh Quarry, S. of Cockenheugh and $2\frac{1}{2}$ miles W. of Belford.
27. Belford, 3 miles W.N.W. of, Old Coal Workings, N. of Cockenheugh Quarry.
28. Belford, ($2\frac{3}{4}$ miles W.N.W. of) Grey Mare Quarry.
29. Girney Nick Old Pit Heaps, $\frac{1}{4}$ mile E. of North Hazelrigg.
30. Lowick Low Dean, Moor House Quarry $1\frac{1}{4}$ mile S.E. of Lowick.
31. Lowick, Hetton Quarry near Hetton Steads, $2\frac{1}{2}$ miles S. of Lowick.
32. Lowick, Hetton Coal Houses, $2\frac{1}{2}$ miles S. of Lowick, Old Quarry.
33. Lowick, Ancroft Stead Limeworks, 3 miles N. of Lowick.
34. Lowick, Dun Quarry (Acre Limestone), $\frac{1}{2}$ mile N. of Lowick.
35. Lowick, Eelwell Quarry.
36. Lowick, Low Dean Old Quarry (between Dun and New Dryburn Quarries, $\frac{3}{4}$ mile N.W. of Lowick).
37. Lowick, New Dryburn Quarry, 1 mile N. of Lowick.
38. Lowick, Bowsden Old Quarry, E. of Bowsden.
39. Lowick, Bowsden Old Quarry, N.E. of Bowsden.
40. Lowick, ($1\frac{1}{4}$ mile S.W. of) Barmoor Red House Quarry.
41. Lowick, Moss Hall Old Quarry, N. of Lowick High Stead, S.W. of Lowick.

42. Elford Quarry, $1\frac{3}{4}$ mile W. of North Sunderland.
43. North Sunderland, Shore Section, $\frac{1}{4}$ mile N.W. of Sea Houses.
44. North Sunderland, Shore Section, 300 yards N.W. of Sea Houses.
45. North Sunderland, Shore and Quarry Section in No. 4 Limestone, S. of Sea Houses.
46. North Sunderland, Shore Section, Sandstone Quarry, a little S. of Sea Houses.
47. Swinhoe, Old Quarry, $\frac{1}{2}$ mile N.E. of Swinhoe and $\frac{3}{4}$ mile W. of Beadnell.
48. Monkshouse, Shore Section near Monkshouse, $1\frac{3}{4}$ miles N. of North Sunderland.
49. Greenhill Rocks, S.E. of Bamburgh.
50. North Sunderland (2 miles S.W. of) Old Quarry between Fleetham and Coldrife.
51. Beadnell, Shore Section, No. 1 Limestone Beadnell Harbour and Point.
52. Beadnell, Shore Section, No. 2 Limestone, Benthall.
53. Beadnell, Shore Section, No. 3 Limestone, Nacker Hole.
54. Beadnell, Shore Section, No. 4 Limestone, E. of Beadnell.
55. Beadnell Quarry, in No. 4 Limestone, S.E. of Church.
56. Beadnell, Shore Section, rather over $\frac{1}{4}$ mile N.E. of Beadnell.
57. Beadnell, Shore Section, Limestone rather over $\frac{1}{2}$ mile N.E. of Beadnell (Collith Hole).
58. Beadnell, Shore Section, No. 5 Limestone, opposite Linkhouse, and $\frac{3}{4}$ mile N. of Beadnell.
59. Bamburgh, Shore Section, Harkess Rocks, $\frac{1}{2}$ mile N. of Bamburgh Church.

PLANTÆ.

Ferns.

Calymmatotheca bifida, *L. & H.*, 46.
Rhodea moravica, *Ett. sp.*, 14.
Cardiopteris nana, *Eichwald* sp., 3.
Sphenopteris Dicksonioides, *Göpp.* sp., 14.
 " sp. (*Bgt. Stur*, allied to *S. elegans*, 3, 14.
 " sp., 3, 14.

Lycopodiaceæ.

Stigmaria ficoides, *Brong.*, 14.
Lepidodendron volkmannianum, *Sternb.* = *Lep. affinis* *Sternb.*, *Vers. p.* 180, Pl. LXVIII, fig. 9, 12.

PROTOZOA.

Saccammina Carteri, *Brady*, 33, 35, 39, 41, 55.
 " 34.

ACTINOZOA.

Alveolites depressa, *Flem.*, 1, 32, 43 (?), 44, 48, 51.
 " *septosa*, *Flem.*, 7, 10, 15, 34, 37, 51.
 " sp. 8, 9, 20, 24, 40.
Amplexus coraloides, *Sow.*, 37 (?).
Aulophyllum, 25 (?).
Cladochonus, 32, 49 (?).
Clisiophyllum Bowerbanki, *M. Edw.*, 32 (?).
Cyathophyllum Archiaci ?, *M. Edw.*, 35.
 " *Murchisoni*, *M. Edw.*, 1, 22, 37, 48, 49, 58.
 " *regium*, *Phill.*, 37 (?).
 " sp., 7, 34, 40 (?), 50, 54.
Heterophyllia granulata, *Duncan*, 1.
 " sp., 40.
Lithostrotion irregulare, *Phill.*, 35, 58.
 " *juncinum*, *Flem.* 1, 6, 8, 25, 31, 32, 35, 37 (?), 38, 40, 43, 44, 48, 58.
 " *Portlocki*, *M. Edw.*, 1, 7, 32, 40.

Lonsdaleia floriformis, *Martin*, 37, 51.
 " sp., 48, 57.
 Michelinia favosa ?, *Goldsf.*, 39.
 " 32.
 Monticulipora (Chaetetes) tumida, *Phill.*, 1, 33, 34, 35, 38, 39, 40, 45, 48,
 49, 55.
 Palaeacis cyclostoma, *Phill.*, 33, 39, 56.
 Syringopora geniculata, *Phill.*, 25 (?), 37 (?), 40, 51, 54.
 " ramulosa, *Goldsf.*, 1, 32, 37 (?), 54.
 " reticulata, *Goldsf.*, 51.
 " sp. 6 (?), 26, 35, 43, 50.
 Zaphrentis (Campophyllum) cylindrica, 49.
 " Phillipsi, 33, 39 (?), 40.
 " sp., 20, 34, 42 (?), 45, 52, 55.

ECHINODERMATA.

Archaeocidaris (plate and spines), 1, 8, 20, 32, 40.
 Achistrum, 33, 34, 40.
 Actinocrinus, 45, 54, 55.
 Cheirodota, 33 (?), 34, 40 (?).
 Crinoid stems, 19, 32, 34, 35, 41, 42, 45, 47, 55.
 " fragments, 8, 9, 26, 34, 39, 40.
 Platycrinus, 49, 55 (?).
 Poteriocrinus crassus, *Miller*, 19, 43.
 " nuciformis, *McCoy*, 34.
 " sp., 1, 20, 22, 33, 35, 39, 40, 44, 45, 48 (?), 49, 50, 54, 55, 58, 59.
 Rhodocrinus, 1, 39, 40.

ANNELIDA.

Worm burrows, 33.
 Spirorbis caperatus, *McCoy*, 40.
 " helicteres, *Salt.*, 29.
 " pusillus, *Martin* (=carbonarius, *Mart.*) 40.

CRUSTACEA.

Griffithides longiceps, *Portl.*, 33.
 " (glabella), 21.
 " 26, 56.
 Phillipsia Eichwaldi, var. mucronata, *McCoy*, 16, 17, 18.
 " Eichwaldi, *Fisch.*, 30, 34, 37, 45, 55.
 " (tail of), 54.
 Dithyrocaris Colei *Portl.*, 33, 34.
 " tenuistriata, *McCoy*, 14 (?).
 " (buccal plates), 39.

OSTRACODA OR ENTOMOSTRACA.

Bairdia ampla, *Reuss*, 33, 34.-
 " amputata, *Kirkby*.
 " brevis, *J. & K.*, 34.
 " Hisingeri, *Münst*, 33.
 " plebeia, *Reuss*, 33, 34, 40.
 " subelongata, *J. & K.*, 33, 40.
 " submucronata, *J. & K.*, 33, 34, 40.
 " sp.
 Beyrichia arcuata, *Beau.*
 " radiata, *J. & K.*, 34.
 Bythocypris bilobata, *Münst*, 33, 34.
 " Phillipsiana, *Jones & Holl*, 34.
 " cornigera, *J. & K.*, 33 (?), 34.
 " cuneola, *J. & K.*, 33, 34, 40.
 Cytherella recta, *J. K. & B.*, 34.
 " reticulosa, *J. & K.*, 34.

Cytherella ? scrobiculata, *J. K. & B.*, 33, 34.
 sp., 33, 40.
 Kirkbya permiana, *Jones*, 33.
 " umbonata, *D'Eichwald*, 33.
 " Urei, *Jones*, 33.
 Leperditia Okeni, *Münst*, 34.
 Ulrichia bituberculata, *M'Coy*, 34.

POLYZOA.

Diastopora megastoma, *M'Coy*, 1, 32, 35, 40, 54, 58.
 Monticulipora tumida, *Phill.*, 54.
 Fenestella carinata, *M'Coy*, 34 (?), 54.
 " membranacea, *Phill.*, 16, 53 (?).
 " plebeia, *M'Coy*, 36.
 " sp., 17, 18, 33, 40, 42, 45, 54, 55, 57.
 Glauconome sp., 34 (?), 45.
 Polypora dendroides, *M'Coy*, 35.
 Pustulopora spicularis, *Phill.*, 35 (?).
 Retepora, 54.
 Rhabdomeson gracile, *Phill.*, 11 (?), 45, 47.
 " rhombiferum, *Phill.*, 37, 42, 45.
 " sp., 34, 54.
 Sulcoretepora rericostata, *M'Coy*, 45.

BRACHIOPODA.

Athyris ambigua, *Sow.*, 19, 30 (?), 32, 40 (?), 45.
 " Roissyi, *L'Eveillé*, 13, 33, 35, 37 (?), 39 (?), 40, 45.
 " sp., 1, 25, 36, 54, (?), 55.
 Cainarophoria crumena, *Martin*, 8 (?), 45 (?).
 Chonetes buchiana, *De Kon.*, 34.
 " laguessiana, *De Kon.*, 2, 11, 15, 18, 23, 28, 31, 33, 34, 35, 37, 39,
 45, 54, 56.
 " polita, *M'Coy*, 54, 55.
 " sp., 51.
 Discina nitida, 21, 33, 34, 38.
 sp., 39.
 Lingula mytiloides, *Sow.*, 15, 33.
 " squamiformis, *Phill.*, 15, 21.
 " sp., 13.
 Orthis Michelini, *L'Eveillé*, 19, 24, 33, 35, 38, 45, 54, 55, 57.
 " resupinata, *Martin*, 22, 25, 36, 45, 47, 52.
 " sp., 42.
 Productus aculeatus, *Martin*, 36.
 " costatus, *Sow.*, 32 (?), 34, 45.
 " fimbriatus, *Sow.*, 16 (?), 25, 35, 37.
 " giganteus, *Martin*, 1, 9, 10, 19, 22, 25, 26, 31, 32, 34, 35, 37, 38,
 39, 40, 42, 43, 45, 47, 48, 49, 50, 51, 54, 55, 57, 58.
 " humerosus ?, *Sow.*, 51.
 " longispinus, *Sow.*, 16, 19, 24, 30, 31, 33, 34, 36, 37, 38, 39, 44, 45
 52, 54, 55.
 " punctatus, *Martin*, 19, 35, 37, 45.
 " var. elegans, *M'Coy*, 52.
 " pustulosus, *Phill.*, 23 (?), 34, 40 (?), 45.
 " scabriculus, *Martin*, 15, 23, 45, 54, 55.
 " semireticulatus, *Martin*, 8, 10, 15, 16, 18, 25, 32, 35, 37 40 (?)
 45, 55, 57.
 " sinuatus, *de Kon.*, 31 (?).
 " spinulosus, *Sow.*, 31.
 " undatus, *Def.*, 2 (?).
 " youngianus, *Dav.*, 36 (?), 45 (?).
 " sp., 7, 11, 21.
 Rhynchonella acuminata, *Martin*, 25 (?), 45.
 " pleurodon, *Phill.*, 18, 37.

Spirifera glabra, *Martin*, 19 (?), 35, 39 (?), 45 (?).
 " grandicostata ?, *M'Coy*, 35.
 " lineata, *Martin*, 8, 35, 37, 45, 55 (?).
 " trigonalis, *Martin*, 1, 9, 16, 19, 22, 24, 30, 31, 32, 34, 35, 37, 38,
 39, 42, 44, 45, 52, 54, 55.
 " 33, 56.
 Spiriferina insculpta, *Phill.*, 33.
 " laminosa, *M'Coy*, 36 (?), 40.
 Streptorhynchus crenistria, *Phill.*, 11, 13, 15, 19, 26, 28 30, 35, 36, 37, 38,
 42 (?), 45.
 Strophomena rhomboidalis, var. analoga, *Phill.*, 8, 26.
 Terebratula (*Dielasma*) gillingensis, *Dav.*, 35.
 " hastata, *Sow.*, 30, 36.
 " 10, 37, 54.

*MOLLUSCA.**Lamellibranchiata.*

Aviculopecten cælatus, *M'Coy.*, 37.
 " sp. 45.
 Cardiomorpha ?, 18.
 Ctenodonta, 14.
 Edmondia sulcata, *Phill.*, 21 (?), 45 (?).
 " 18.
 Leptodemus (*Sanguinolites*) costellatus, *M'Coy*, 18, 34, 54.
 " fragilis, *M'Coy*, 37 (?).
 Modiola (*Lithodomus*) Jenkinsoni, *M'Coy*, 35.
 " 35.
 Myalina, 35, 38.
 Nucula brevirostris, *Phill.*, 39 (?).
 " gibbosa, *Flem.*, 33, 34, 37, 39.
 " sp., 36. (?)
 Nuculana (*Leda*) attenuata, *Flem.*, 28 (?).
 Pecten Sowerbyi, *M'Coy*, 17, 36.
 Pleurorhynchus, 35.
 Posidonomya Becheri, *Bronn*, 11, 14, 15, 23.
 Sanguinolites oblongus, *Portl.*, 45.
 " variabilis ?, *M'Coy*, 39.
 " sp., 54.
 Schizodus sp., 15, 15 (?), 21, 27, 37.
 Solemya primæva, *Phill.*, 4 (?), 8 (?), 9, 50.

Gasteropoda.

Bellerophon cornu-arietis, *Sow.*, 45 (?), 55 (?).
 " (*Euphemius*) decussatus, *Flem.*, 14, 34.
 " " interlineatus, *Portl.*, 18.
 " " Urei, *Flem.*, 14, 23, 33, 34, 37, 39
 " " sp., 15, 27, 29, 49.
 Microdoma quadrirerrata, *De Koninck*, 42.
 Porcellia, 42.
 Dentalium (*Entalis*) priscum, *Goldf.*, 18 (?), 33, 34.
 Euomphalus carbonarius, *Sow.*, 33, 34, 37, 39, 54.
 " sp., 18, 20.
 Loxonema rugiferum, *Phill.*, 33, 34, 37.
 " sp., 36 (?).
 Macrochilina, 33.
 Naticopsis elongata, *Phill.*, 54.
 " plicistria, *Phill.*, 55.
 " sp. 35, 55.
 Pleurorhynchus, 35.
 Pleurotomaria (*Ptychomphalus*) atomaria, *Phill.*, 33, 34,
 interstrialis, *Phill.*, 33.
 " (*Mourlonia*) naticoides, *De Kon.*, 33.
 " (*Baylea*) Yvani, *L'Eveillé*, 54.
 Turbo, 36.

CEPHALOPODA.

Actinoceras giganteum, *Sow.*, 19.
 " 43.
 Cyrtoceras (Meloceras) rugosum, *Flem.*, 42.
 Discites, 35.
 Goniatite, 18, 33.
 Nautilus, 38.
 Orthoceras, cinctum, *Sow.*, 39.
 " reticulatum, *Phil.*, 34.
 " sulcatum, *Flem.*, 18, 33, 34, 39, 54.
 " sp. 17, 25, 49, 53.

PISCES.

Fish remains, 5, 19, 33, 35, 39, 54, 55.
 Dicrenodus, 34 (?).
 Helodus, 34.
 Petalodus, 36.
 Psammodus, 54.
 Rhizodus, 14.
 Strepsodus, 27.

B.—FOSSILS FROM THE CARBONIFEROUS LIMESTONE OF LOWICK, NORTHUMBERLAND.

In Sedgwick and M'Coy's Palaeozoic Fossils. Names revised by MR. SHARMAN.

Aulophyllum fungites, *Flem.* = Clisiophyllum prolapsnm, *M'Coy*.
 Lithostrotion irregulare, *Phil.* = Diphyphyllum gracile, *M'Coy*.
 " junceum, *Flem.* = Siphonodendron sexdecimale, *Phil.*
 Athyris ambigua, *Sow.*
 " plano-sulcata, *Phil.* = A. paradoxa, *M'Coy*.
 Camarophoria ? latidivisa, *M'Coy*.
 Chonetes polita, *M'Coy* = Leptæna polita, *M'Coy*.
 Discina nitida, *Phil.* = D. bulla, *M'Coy*.
 Orthis resupinata, *Mart.* = O. (Spirifera) connivens, *Phil.*
 Productus aculeatus, *Mart.*
 " cora, *D'Orb.* = P. corrugatus, *M'Coy*.
 " costatus, *Sow.* = P. sulcatus, *Sow.*
 " fimbriatus, *Sow.*
 " giganteus, *Mart.*
 " longispinus, *Sow.* = P. setosus, *Phil.*, P. Flemingi, *Sow.*, P. lobatus, *Sow.*
 " punctatus, *Mart.* = P. elegans, *M'Coy*.
 " semireticulatus, *Mart.* = P. (Martini) pugilis, *Phil.*
 " scabriculus, *Mart.*
 " striatus, *Fisch.*
 " undatus, *Defr.* = P. tortilis, *M'Coy*.
 Rhynchonella gregaria, *M'Coy* = Athyris gregaria, var. trapezoidalis,
 " *M'Coy*.
 " (Hemithyris) pleurodon, *Phil.*
 " pugnus, *Mart.* = Hemithyris acuminata, var. pugnus,
 " *M'Coy*.
 Spirifera duplocostata, *Phil.*
 " glabra, *Mart.* = S. symmetrica, *Phil.*
 " (Reticularia) lineata, *Mart.*
 " ovalis, *Phil.*
 " trigonalis, *Mart.* var. bisulcata, *Sow.*
 Stictoprymnus crenistria, *Phil.* = Leptaena (Strophomena) cylindrica,
M'Coy; = Leptaena (Strophomena) Kellyi, *M'Coy*.
 Dielasma (Terebratula) hastata, *Sow.* = Seminula virgoides, *M'Coy*.
 Avicula (Pterinea) levigata, *M'Coy*.

Aviculopecten cancellatus, *M'Coy*.
 " *cœlatus*, *M'Coy*.
 " *concavus*, *M'Coy*.
 " *conoideus*, *M'Coy*,
 " *fimbriatus*, *Phil.*
 " *flexuosus*, *M'Coy* = *A. docens*, *M'Coy*.
 " *granosus*, *Sow.*
 " *Ruthveni*, *M'Coy*.
 " *segregatus*, *M'Coy*.
Pecten (*Amusium* ?) *deornatus*, *Phil.*
 " *Sowerbyi*, *M'Coy*.
Pteronites persulcatus, *M'Coy*.
Streblopteria (*Pecten*) *elongata*, *M'Coy*.
 " (*Meleagrina*) *lavigata*, *M'Coy*.
 " (*Avicula*) *pulchiella*, *M'Coy*.
Anodontopsis ? *pristina*, *M. V. K.*
Protoschizodus (*Myophoria*) *axiniformis* var. *depressus*, *Portl.*
 " *obliquus*, *M'Coy*.
Cardiomorpha (*Edmondia*) *Egertoni*, *M'Coy*.
 " *oblonga*, *Sow.*
Conocardium *aliforme*, *Sow.*
Edmondia *Josephae*, *De Kon.*
 " (*Sanguinolaria*) *phaseolina*, *Goldf.*
 " *rudis*, *M'Coy*.
 " *scalaris*, *M'Coy*.
 " *sulcata*, *Phil.*
 " (*Isocardia*) *unioniformis*, *Phil.*
Leptodomus costellatus, *M'Coy*.
Modiola (*Lithodomus*) *Jenkinsoni*, *M'Coy*.
Pinna flabelliformis, *Martin* = *flexicostata*, *M'Coy*.
 " *spatula*, *M'Coy*.
Sanguinolites iridinoides, *M'Coy*.
 " *striato-lamellosus*, *De Kon.*
 " *sub-carinatus*, *M'Coy*.
 " *sulcatus*, *Flem.*
 " *tricostatus*, *Portl.*
 " *variabilis*, *M'Coy*.
Solemya ? *primæva*, *Phil.*
 " var. *puzoziana*, *De Kon.*
Conularia quadrisulcata, *Sow.*
Bellerophon apertus, *Phil.* = *B. Phillipsii*, *M'Coy*.
 " *Larcomi*, *Portl.*
 " *recticostatus*, *Portl.*
 " (*Euphemus*) *decussatus*, *Flem.*
 " (*Waagenella*) *Dumonti*, *D'Orb.*
Dentalium (*Entalis*) *ornatum*, *De Kon* = *D. dentaloideum*, *M'Coy*.
Euomphalus (*Straparollus* ?) *catillus*, *Sow.*
 " { " } *costellatus*, *M'Coy*.
 " { " } *pentangulatus*, *Sow.*
 " { " } *tabulatus*, *Phil.*
Loxonomena rugiferum, *Phil.*
Murchisonia dispar, *M'Coy*.
Macrochilina acutus, *Sow.*
 " *brevispiratus*, *M'Coy*.
 " *limnæiformis*, *M'Coy*.
 " *sigmalineus*, *Phil.*
 " ? *spiratus*, *M'Coy*.
Naticopsis variata, *Phil.*
Platyschisma glabrata, *Phil.*
 " *helicoides*, *Sow.*
Pleurotomaria altavittata ? *M'Coy*.
 " *decipiens*, *M'Coy*.
Pleurotomaria erosa, *M'Coy*.
 " (*Mourlonia*) *Griffithi*, *de Kon.*

Polytremaria catenata, *de Kon.*
 Straparollus Dionysi, *de Mont.* = *S. rotundatus, Sow.*
 Actinoceras (Orthoceras) Breyni, *Mart.* = *O. laterale, Phil.*
 " " giganteum, *Sow.*
 " Sowerbyi, *M'Coy.*
 Cœlonautilus (Discites) quadratus, *Flem.*
 " globatus, *Sow.*
 Cyrtoceras (Meloceras) rugosum, *Flem.*
 Discites (Phacoceras) oxystomus, *Phil.*
 Ephippioceras (Nautilus) bilobatus, *Sow.*
 Glyphioceras (Goniatites) reticulatus, *Phil.*
 Orthoceras (Cycloceras) Flemingi, *M'Coy.*
 " fusiforme, *Sow.*
 " inaequiseptum, *Phil.*
 " sulcatum, *Flem.*
 " vennense, *Foord* (*cylindraceum, Flem.*)
 Poterioceras cordiforme, *M'Coy.*
 " ? cornu-vaccinum, *M'Coy.*
 Solenocheilus (Nautilus) ingens, *Mart.*
 Temnocheilus { " } coronatus, *M'Coy.*
 " { " } costato-coronatus, *M'Coy.*
 Acondylacanthus (Leptacanthus) Jenkinsoni, *M'Coy.*
 Cladodus striatus, *Ag.*
 Xystrodus (Cochliodus) striatus, *Ag.*
 Petalodus acuminatus, *Ag.*
 " Hastingsiae, *M'Coy* (*non Owen*).
 " rectus, *Ag.* (?*Polyrhizodus magnus, M'Coy.*)
 Pœciilodus Jonesi, *Ag.*
 Psephodus (Cochliodus) magnus, *M'Coy* = *Helodus planus, M'Coy.*
 Psammodus rugosus, *Ag.* = var. *porosus, M'Coy.*
 " (Copodus) cornutus, *Portl.*

C.—CARBONIFEROUS FOSSILS FROM THE COLLECTION OF
 G. TATE IN ALNWICK MUSEUM.

(Specimens named by MR. R. ETHERIDGE.)

DRYBURN :

Streptorhynchus crenistria, *Phil.*
 Aviculopecten cœlatus, *M'Coy.*
 " sp.
 Sanguinolites variabilis, *M'Coy.*
 Schizodus, sp.
 Euomphalus tabulatus, *Phil.*

FARNE :

Lingula mytiloides, *Sow.*
 Productus longispinus, *Sow.* (*Flemingi, Sow.*).
 Spiriferina cristata var. octoplicata, *Sow.*

FARNE ISLAND :

Griffithides farnensis, *Tate* = *Phillipsia Eichwaldi*, var. *mucronata*,
Fisch.

FOSSLAND :

Discina nitida, *Phil.*
 Lingula mytiloides, *Sow.*
 Productus longispinus, *Sow.* (*Flemingi, Sow.*).
 Cœlonautilus globatus, *Sow.*

HOLY ISLAND, or LINDISFARNE :

Productus longispinus, *Sow.* (*Flemingi, Sow.*).
 Nucula brevirostris, *Phil.*
 Protoschizodus axiniformis, var. *depressus*, *De Kon.*

Leptodomus costellatus, *M'Coy*.
Bellerophon (*Euphemus*) *decussatus*, *Flem.*
 " " *striatus*, *Flem.*
 " " *Urei*, *Flem.*
Capulus trilobus, *Phil.*
Euomphalus carbonarius, *Sow.*
Cœlonutilus cariniferus, *Sow.*
Discites sulcatus, *Sow.*
Ephippioceras bilobatus, *Sow.*
Nautilus perplanatus, *Portl.*
Orthoceras goldfussianum, *De Kon.*
 " *pyramdale*, *Flem.*
 " *sulcatum*, *Flem.*

LOWICK :

Productus cora, *D'Orb.*
 " *semireticulatus*, *Martin* (*concinus*, *Sow.*).
 " *fimbriatus*, *Sow.*
 " *giganteus*, var. *hemisphericus*, *Sow.*
 " *latissimus*, *Sow.*
 " *longispinus*, *Sow.* (*Flemingi*, *Sow.*).
Spirifera (*Reticularia*) *lineata*, *Mart.*
 " *trigonalis*, *Mart.*
Aviculopecten cœlatus, *M'Coy*.
Pinna flabelliformis, *Mart.* (*flexicostata*, *M'Coy*).
Arca cancellata, *Sow.*
Edmondia sulcata, *Phil.*
Schizodus (*Myophoria*) *carbonarius*, *Sow.*
Sanguinolites ? *arcuata*, *Phil.*
 " *iridinoides*, *M'Coy*.
Solemya primæva, *Phil.*
Bellerophon apertus, *Sow.*
 " *hiulcus*, *Sow.*
Dentalium (*Entalis*) *ornatum*, *De Kon.* (*dentaloideum*, *M'Coy*).
Euomphalus catillus, *Sow.*
Loxonema tumida, *Phil.*
Naticopsis ampliata, *Phil.*
 " *plicistria*, *Phil.*
Glyphioceras (*Goniatites*) *stenolobus*, *Phil.*

EELWELL :

Productus latissimus, *Sow.*
 " *spinulosus*, *Sow.*

BEAL .

Euomphalus catillus, *Sow.*

BELFORD :

Orthis (*Spirifer*) *arachnoidea*, *Phil.*

HETTON :

Productus costatus, *Sow.*
 " *giganteus*, var. *hemisphericus*, *Sow.*
 " *semireticulatus*, var. *Martini*, *Sow.*
Spirifera glabra, *Mart.*
 " (*Reticularia*) *lineata*, *Mart.*
 " *striata*, *Mart.*
 " *trigonalis*, *Mart.*
Conocardium rostratum, *Mart.*
Edmondia sulcata, *Phil.*
Sanguinolites (*Edmondia*) *oblonga*, *Portl.*
Solemya primæva, *Phil.*
Bellerophon apertus, *Sow.*
 " *hiulcus*, *Sow.*
Straparollus Dionysi, *Goldf.*

BUDLE :

Orthis Michelini, *Sow.*
Streptorhynchus crenistria, *Phil.*
Pinna flabelliformis, *Martin.*
 flexicostata , *M'Coy.*
 " *Becheri*, *Goldsf.*
Leptodus costellatus, *M'Coy.*
Nuculana (Leda) attenuata, *Flem.*
Bellerophon (Euphemus) striatus, *Flem.*
Euomphalus carbonarius, *Sow.*
Macrocheilina ovalis, *M'Coy*
Orthoceras attenuatum, *Flem.*
 " *sulcatum*, *Flem.*

BAMBURGH :

Sanguinolites arcuatus, *Phil.*

BEADNELL :

Productus giganteus, *Mart.*
 longispinus , *Sow.*
 " *Orthoceras cylindraceum*, *Flem.*
Actinoceras gigantium, *Sow.*
Orthoceras sulcatum, *Flem.*

NORTH SUNDERLAND :

Orthis Michelini, *Sow.*
 "resupinata , *Mart.*
Productus semireticulatus, *Mart.*
Spirifera (Reticularia) lineata, *Mart.*
 "trigonalis , *Mart.*
 " *var. bisulcatus*, *Sow.*
Streptorhynchus crenistria, *Phil.*
Aviculopecten docens, *M'Coy.*
 "meleagrinooides , *M'Coy.*
Edmondia sulcata, *Phil.*
Sanguinolites iridinoides, *M'Coy.*
 "undatus , *Sow.*
 "variabilis , *M'Coy.*
Bellerophon (Euphemus) Urei, *Flem.*
Euomphalus carbonarius, *Sow.*
Loxonema rugifera, *Phil.*
Naticopsis plicistria, *Phil.*
Orthoceras goldfussianum, *De Kon.*
 "sulcatum , *Flem.*

D.—A LIST OF FOSSILS FROM THE SCREMERSTON LIMESTONE, SOUTH OF BERWICK.

(From Lebour's *Geology of Northumberland*, p. 123 (2nd ed.).)

The following were observed in a washing from a band in the Scremerston limestone :—

Climacammina antiqua, *Brady*, very rare.
Endothyra Bowmani, *Phill.*, rare.
 "radiata , *Brady*, rather scarce.
Stacheia polytrematoides, *Brady*, rather scarce.
Textularia eximia, *d'Eich.*, very rare.
Trochammina incerta, *d'Orb.*, common.
Valvulina paleotrochus, *Ehrenb.*, rare.
 " " *var. compressa*, *Brady*, moderately common

Valvulina decurrens, *Brady*, common.
 " plicata, *Brady*, very rare.
 Stenopora tumida, *Phill.*
 Archæcidaris sp., various small spines.
 Encrinital remains.
 Spirorbis globosus ?, *M'Coy*.
 Entomostraca, common.
 Glaucomea flexi-carinata, *Y. and Y.*.
 Hyphasmopora Buski, *Eth.*
 Rhabdomeson gracile, *Y. and Y.*
 " rhombiferum, *Y. and Y.*
 Chonetes buchiana ?, *De Kon.*
 Lingula sp.
 Productus semireticulatus, *Mart.*
 Spirifera glabra, *Mart.*
 sp.
 Streptorhynchus crenistria, *Phill.*
 Loxonema polygyra ?, *M'Coy*, cast.
 Ctenoptychius serratus, *Ag.*
 Numerous small fish remains.

E.—A LIST OF FOSSILS FROM THE LAMBERTON LIMESTONE, THREE MILES NORTH OF BERWICK.

(From Lebour's *Geology of Northumberland*, p. 124 (2nd ed.).)

The following were observed in a washing taken from the limestone :—

Archædiscus Karreri, *Brady*, rare.
 Endothyra radiata, *Brady*, rare.
 Saccammina Carteri, *Brady*, single specimen.
 Stacheia acervalis, *Brady*, rare.
 " congesta, *Brady*, rare.
 " fusiformis, *Brady*, rare.
 " polytrematoides, *Brady*, rather scarce.
 Trochammina incerta, *d'Orb.*, very common.
 Valvulina decurrens, *Brady*, moderately common.
 " palæotrochus, *Ehrenb.*, common.
 " var. compressa, *Brady*, rare.
 " plicata, *Brady*, rather scarce.
 Stenopora tumida, *Phill.*
 Archæcidaris sp., plates.
 Encrinital stems, &c.
 Ortonia carbonaria, *Young*.
 Spirorbis, sp.
 Entomostraca, rather scarce.
 Ceriopora interporosa, *Phill.*
 Fenestella, sp.
 Glaucomea marginalis, *Y. and Y.*
 " retroflexa, *Y. and Y.*
 " sp.
 Hyphasmopora, sp.
 Polypora, sp.
 Sulcoretipora parallela, *Phill.*
 Spirifera, sp.
 Productus giganteus, extremely abundant.

F.—SOME FOSSILS FROM LISTS GIVEN IN THE GUIDE
TO THE COLLECTIONS IN NEWCASTLE MUSEUM,
BARRAS BRIDGE.

PLANTÆ.

Asterocalamites scrobiculatus (*Schloth.*) Petrefact, pl. 20, fig. 4. Newton,
near Chillingham.

Lepidodendron veltheimianum (*Sternb.*) Vers., pl. 68, fig. 14. In
sandstone, Alnwick Moor.

ACTINOZOA.

Cyathophyllum regium, *Phill.*

MOLLUSCA.

Lamellibranchiata.

Posidonomya Becheri, *Goldf.* In shale, Budle Bay.
Edmondia sulcata, *Phill.* Lowick.

Gasteropoda.

Murchisonia angulata, *Phill.* Lowick.
Loxonema tenuistriata, *Portl.* Lowick.

Cephalopoda.

Actinoceras giganteum, *Sow.* Holy Island.

PISCES.

Petalodus acuminatus, *Ag.* Whorlton-on-Tees.

Rhizodus Hibberti, *Ag.* & *Hibb.* Scremerston & Norham (G. Tate).

Psephodus magnus, and *striatus*, *Ag.* Lowick (M'Coy). (M.D.)

Psammodus rugosus, *Ag.* Lowick (M'Coy).

Acondylacanthus (*Leptacanthus*) *Jenkinsoni*, *M'Coy.* Lowick.

Ctenodus, sp. Norham. G. Tate.

Callopristodus (*Ctenoptychius*) *pectinatus*, *Ag.* Norham. G. Tate.

G.—A LIST OF FOSSIL PLANTS FROM THE LOWER
CARBONIFEROUS.

The following species of fossil plants are given on the authority of Mr. G. Tate, in "Fossil Flora of the Mountain Limestone of the Eastern Borders," an appendix to Johnston's "Natural History of the Eastern Borders." The names have been revised by R. Kidston, Esq.

Stigmaria ficoidea, *Brongt.* Frequent. Budle, &c.

Lepidodendron selaginoides, *Sternb.* (? *Veltheimianum*, *Sternb.*)
Barmoor in a carbonaceous shale.

Sphenopteris elegans, *Brongt.* (*S. Johnstoniana*, *Tate.*) Figs. 1 and
2, pp. 306, 307. Budle, in shale.

Rhacopteris (*Sphenopteris*) *flabellata*, *Tate.* Fig. 3, p. 108. Budle,
in shale.

Rachis of fern. Plate xiii., fig. 1. (*Filicites striata*, *Tate.*) Budle,
in shale.

Asterocalamites scrobiculatus, *Schloth.* foliage of. Plate xiii., fig. 9.
(*Bechera simplex*, *Tate.*) Budle, in shale.

Cardiocarpus (*Carpolithes*) *ovatus*, *Tate.* Plate xiii., figs. 7 and 7a.
Bamburgh in a red slaty sandstone, along with other obscure
vegetable remains.

The following are on the authority of Mr. Tate alone :—

Knoria taxine, *Lindl.* Budle, in shale.

Poacites nervosa, *Tate.* Plate xiii., fig. 5. Budle, in shale.

Crinites lanceolatus, *Tate.* Plate xiii., fig. 6. Budle, in shale.

? *Filicites intercostata*, *Tate.* Plate xiii., figs. 4 and 4a. Budle, in
shale.

II.—VERTICAL SECTIONS OF STRATA.

BELFORD.

Account of the Boring at Belford about 300 yds. to the north-east from Whinney Hill, July 1st, 1763. (From Vol. 1 of Views and Borings, presented by Dixon Dixon, Esq., p. 583. Museum of Newcastle Antiq. Soc.).

	Ft. In.	Ft. In.
Soil and stony clay with a mixture of sand and a small spring of water.	7 6	
Sand and water	1 6	
Seavy clay (probably smooth)	4 6	
Stony clay	6 0	19 6
Blue grey mettle stone with girdle	65 6	
Mixture whin	1 0	
Strong limestone or whin	15 0	
COAL	0 7	82 1
Dunnish grey mettle	0 6	
Grey mettle	2 0	
Grey and brown post, and set away the water	13 6	
White and grey post	8 6	
Grey mettle stone	21 0	
Whin and strong limestone	2 2	
Grey mettle with girdle	13 6	
COAL	0 5	61 7
Strong white post with water	18 0	
Grey mettle	6 9	
Foul COAL	0 7	
Black and grey mettle with brassy girdles and some sparkles of coal.	1 2	
COAL with water	0 6	27 0
Grey mettle	2 9	190 2
In whin or stong limestone	0 3	3 0
Total		193 2

K

BEADNELL.

Borings for Coal at Beadnell, near to the lime-kiln, on the links between Beadncell and Annstead. Feb. 20, 1862. Property of T. W. Craster, Esq. From W. Wilson, Alnwick.

	Ft.	In
Limestone	5	0
COAL	0	4
Metal	7	0
COAL	0	7
Black biddy metal	2	6
Blue metal	0	6
Biddy freestone beds	0	10
Metal	0	3
Freestone	0	
Metal	0	3
Freestone	0	6
Metal	0	2
Freestone	0	10
Metal	0	3
Freestone	0	5
Metal	0	2
Freestone bands	0	.8
Black metal	0	3
Freestone	0	8
Black metal	0	3
Freestone (bands)	1	3
Metal parting	0	6
Freestone	2	0
Metal	0	8
Freestone	2	9
Metal	0	9
Freestone (very hard)	2	6
Metal	0	7
Freestone (band)	1	9
Metal	0	6
Freestone	2	9
Parting	0	5
Freestone post	5	1
	43	5

ELWICK.

The series of borings at Elwick of which details are given below, was made in a nearly north-east direction alongside a fence stretching from the burn to the sea, a distance of more than three-quarters of a mile, nearly midway between the two Ordnance Stations marked $\Delta 75$ and $\Delta 64$ to the west of Elwick. The fence comes down to the sea a little west of the Station $\Delta 34$. About 300 yds. north-east from the road a "well" is marked on the six-inch Map. This is filled up, but is said to have been an old coal pit—the section of which is :—

	Ft.	In
Clay with boulders	32	0
Soft pale blue metal	12	0
Black metal	1	0
COAL	2	0
Black metal	2	0
	49	0

This is substantially the same account as that of Borehole No. 2, which was, however, continued to a depth of 18 ft. below the coal. The exact position of the other holes could not be ascertained, but No. 3 was probably between the burn and the road as the drift there is thinner than elsewhere, and I was informed that a hole there was nearly all in freestone; and perhaps No. 6 was near there also.

The borings were begun on November 24th, 1873, and the following details were communicated by Mr. Stevenson, of Elwick :—

<i>1st Borehole.</i>	Ft. In.
Soil and clay	27 0
Blue metal	14 0
Limestone	3 0
Soft metal, but broke the chisel-screw and discontinued.	—
	<hr/>
	44 0
<i>2nd Borehole.</i>	Ft. In.
Soil and clay	32 0
Soft pale blue metal	12 0
Black metal	2 0
COAL	2 0
Blue metal	10 0
Biddy sandstone	8 0
	<hr/>
	66 0

This 2nd hole is close to the coal-pit the section of which has been given previously (see p. 49).

<i>3rd Borehole.</i>	Ft. In.
Soil and clay	8 0
Biddy sandstone	31 0
Red sandstone	18 0
Red sandstone	5 0
Blue metal	1 0
Biddy sandstone with metal partings	7 0
Limestone	0 8
	<hr/>
	70 8
<i>4th Borehole.</i>	Ft. In.
Soil and clay	8 0
Blue metal	3 0
Sandstone bands with metal partings	10 0
Blue metal	2 0
Hard stene	5 0
	<hr/>
	28 0

The 4th hole stopped by getting into a slant gullet.

<i>5th Borehole.</i> Could not get down further for sand and gravel.	21 ft.
<i>6th Borehole.</i>	Ft. In.
Soil and clay	10 0
Blue metal	3 0
Sandstone bands	4 0
Blue metal	3 0
Hard flint stone	8 6
Blue metal	3 0
Biddy sandstone	44 0
Hard sandstone bands	37 0
Blue metal	6 0
Hard sandstene bands	3 0
	<hr/>
	121 6

<i>7th Borehole.</i>	Ft. In.
Soil and clay	35 0
Limestone	15 6
Blue metal	18 0
	<hr/>
	68 6

<i>8th Borehole.</i>	Ft. In.
Soil, clay, sand, and gravel	30 0

<i>9th Borehole.</i>	Ft.	In.
Soil and clay	27	0
Blue metal	12	0
Freestone bands	4	6
	43	6

BROWNRIGG.

Account of strata bored through in a field named the Intake, west of Brownrigg House, and belonging to J. Jackson, Esq., Lowick.

	Ft.	In.
Soil and clay	4	6
Limestone	3	0
Tills	25	6
COAL	1	0
Tills	14	10
Very hard freestone	4	0
Soft stone	1	11
Hard stone	4	5
Tills	24	3
Hard stone	1	9
Tills	1	9
COAL	1	2
Tills	2	2
	90	3

Account of the 2nd Borehole in the same field, supposed straight rise from the other borehole, 100 yds.

	Ft.	In.
Soil and clay	6	0
Freestone	6	0
Hard stone	16	10
Milder stone	1	9
Tills	2	3
COAL	1	2
Soft metal	0	9
Freestone	1	3
	36	0

Supposed straight rise from the other two boreholes as far as other side, and close up to Mr. Fennell's March—the name of field—*Big Island*.

	Ft.	In.
Clay and soil	12	0
White freestone	4	0
Dun freestone almost the colour of clay	10	6
Freestone	21	6
Red freestone	12	6
	60	6

MUCKLE HOWGATE BORINGS.

East Side of the Moor :—	Ft.	In.
Soil and clay, tills	10	0
White metal	6	0
Metal, green cast	2	6
Red metal	5	0
Dark metal	1	6
Very dark metal	4	0
COAL	3	9
Metal	0	4
	33	1

Middle Hole :—		Ft.	In.
Soil and clay	10	0	
COAL	0	6	
Freestone and white metal	11	0	
Metal, green cast	4	0	
Red and green metal	3	6	
Dark metal	6	6	
COAL, good, soft	3	4	

38 10

Northmost Hole :—		Ft.	In.
Soil and clay	5	6	
Tills	4	0	
COAL	0	6	
Limestone	1	0	
Freestone metal	9	0	
Metal, green cast	2	6	
Metal, red cast	6	10	
Metal, dark	3	11	
COAL	2	0	

35 3

BROWN RIGG MOOR.

Series of borings nearly north and south to the Lower Coal in Brownrigg Moor, supposed to be the Little Howgate.

1st Hole, north side of the pit (side of cast running across the Moor) :—

	Ft.	In.
Soil and clay	6	0
Red and white freestone	7	0
Ditto	19	4
Coal	0	10
Metal	0	7
Coal	0	7
Metal	0	9

35 1

2nd Hole, north side of the pit :—

Ft. In.

Soil and clay	4	6
Freestone	7	6
Red freestone	6	4
White and red freestone	26	5
Metal	1	4
COAL	0	11
Metal	1	5
COAL	0	6
Metal	0	4

49 3

Borehole marked No. 4, but probably No. 3 :—

Ft. In.

Soil and clay	7	6
White freestone	10	6
Red freestone	3	6
Metal	1	6
White and red freestone	8	0
White freestone	3	11
Metal	2	0
Dark freestone	5	8
Tills	3	6
COAL	1	1
Metal	2	0

49 2

Hole marked No 3, but probably No. 4. It is against the north side of the moor :—

	Ft. In.
Soil and clay	8 0
Soft freestone	5 10
Hard stone	0 8
Freestone	12 2
Very hard stone	0 11
Freestone	2 0
Red Freestone	19 0
Very red freestone	3 7
Metal	1 0
COAL	0 7
Tills	2 6
Hard stone	0 6
Tills	1 0
Freestone	0 7
Tills	2 2
COAL	0 5
Tills	6 2
Freestone	0 2
	67 3

HOLY ISLAND.

An account of the Stones, Coals and Metalls boared through at the Boar Hole upon Holy Island. By Andrew Wake. For the use of Henry Coll Selby, Esq. 1792. (From 4 copies lent by Revd. Hugh Taylor of Humshaugh-on-Tyne. August 30th, 1881.)

	Ft. In.
Bored in sand	6 0
Clay	7 0
Limestone	3 0
Black dent coal	0 6
Grey metal	0 6
Whin	3 0
White post	24 0
Post girdles with metal partings	6 0
Grey metal	14 0
Blue stone	8 0
Whin	2 0
Blue stone	24 0
Post girdles with metal partings	3 0
Whin, sandwater	1 6
White post	0 6
Whin	1 0
White post	0 6
Whin	6 0
Grey Metal	1 0
Whin	3 0
White post	0 6
Whin	1 0
White post	3 0
Whin	1 0
White post	1 0
Whin	1 0
Blue grey metal	3 0
White metal	12 0
White post	2 6
Blue stone	3 0
Coal	0 6
Grey metal	1 0
Grey stone	.6 0
Grey post	12 0
White post	7 0
Grey stone	0 4
Coal	1 0
Grey metal	0 6
Post girdles with metal partings	3 2

FLEETHAM, NORTH SUNDERLAND.

Account of Strata bored through at Fleetham, North Sunderland, 1857.
(Vol. 3 of Sinkings and Borings, pp. 50, 51.)

No. 1 Hole :

	Ft.	In.
Clay	6	6
COAL	0	6
Grey metal	46	0
Limestone	5	0
Grey metal mixed with COAL	0	3
COAL, good	1	1
Metal	0	4
COAL, slaty	0	10
Into grey metal stone	3	0
	63	6

No. 2 Hole :

	Ft.	In.
Soil and clay	7	6
Metal	43	6
Limestone	6	6
Metal	0	4
COAL	1	3
Metal	0	~
COAL	0	11
Into metal	1	0
	61	3

No. 3 Hole :

	Ft.	In.
Clay	5	0
Limestone	19	0
Metal	9	0
Post	3	0
Metal	13	6
Coal	0	8
Metal	12	0
Post	21	0
Metal	1	0
Coal	0	9
Metal	21	6
Limestone	7	6
Metal	3	9
Coal	0	4
Into metal	0	11
	118	11

BAMBURGH.

Boring at Bamburgh by the Water Level Seam, 100 yds. back from the Sd. Coal Pit, September 4, 1769. (From Vol. 1 of Sinkings and Borings, issued by N. Eng. Inst. Min. Eng.)

	Ft.	In.
Soil and stony clay	10	6
Rambly red and white post with water near the bottom.	25	0
Black metal	10	6
Blue metal	18	6
COAL	1	8
COAL foul	0	4
Black metal	1	0
COAL	0	7
COAL foul	0	5
Black metal	0	5
COAL	1	5
COAL foul	1	0
Black grey metal	1	0
In grey post with water	1	0
	73	4

Second place at Bamburgh, in the bottom of an old pit.

	Ft.	In.
Brown and grey post, with water	27	0
Blue metal	2	0
Limestone	13	0
Blue metal, with hard girdles or lumps	9	0
Grey post	4	0
Blue slaty metal	29	0
Limestone	1	8
COAL	0	5
Grey post	6	0
Blue grey metal, with girdles	18	0
COAL	1	6
Grey metal	2	5
In grey post	13	0
	127	0

HOPPEN BORING.

	1872.	1873.	
	Ft. In.	Ft. In.	
Freestone	21 6	14 Mar.	Hard freestone
Metal tills	3 11	" "	Grey post
Freestone	3 4	16 "	Metal
Metal tills	2 0	17 ..	Grey post
Freestone bands	8 5	18 ..	Hard freestone
Metal tills	4 6	19 ..	" ,
Soft metal	2 2	20 ..	" "
Blue metal (harder)	6 8	21 ..	" "
Freestone	2 0	22 ..	" "
Limestone	1 9	24 ..	" "
Metal tills	2 5½	26 ..	" "
Freestone bands	5 9	27 ..	Grey metal mixed with freestone.
Hard freestone	6 0½	28 ..	Grey metal and freestone
Metal tills	0 6½	" ..	Blue metal
Freestone bands	8 1½	" ..	Grey metal
Blue tills	1 4	29 ..	Grey metal
Freestone	8 8	1 Apr.	Hard freestone
Hard metal	0 9	" "	Grey slate
Black metal	9 1	" "	Grey metal
COAL	0 6	2 ..	Grey metal
Metal tills	1 1½	3 ..	Grey slate
Freestone	6 0	" "	Grey metal
Bastard freestone	0 10	4 ..	Grey slate
Freestone bands	4 2½	" "	Grey stone
Metal tills	5 10	" "	Grey metal
Freestone bands	0 6		
Limestone	4 9		
Metal tills	1 5		
Hard freestone	11 6		
	135 8		
		Bored before	35 9½
			135 8
		From surface to bore-hole.	171 5½
		Total depth of hole	17 0
			188 5½

III. GLOSSARY OF LOCAL AND MINING TERMS OF NORTH NORTHUMBERLAND.

BACK. "On the back of" means farther to the dip, on the top of, or lying above.

BALK or BAULK. A thinning of a coal-seam owing to a sudden depression of the roof, usually a sandstone, into the coal.

BAND. A parting in a coal-seam.

BANDY METAL. Shale with thin sandstone bands.

BANK. Coals are said to be worked *over the bank* when they are worked to the dip side of the shaft or level which drains the mine.

BASSET. The outcrop of a coal-seam or bed of limestone, &c.

BASTARD. Impure, as bastard limestone. Bastard freestone is sandstone that will not cut freely in any direction.

BEARING or RED. The amount of clay or shale, &c., that overlies the limestone or sandstone in a quarry.

BEDDY or BIDDY. Arranged in thin beds or layers.

BLAES or BLUE. Shale.

BLUE STONE. Limestone.

BOARDS. The name given to the successive breadths of coal excavated in the method called "board and pillar" or "post and stall" work.

BOTTOM COAL. The lowest part of a coal-seam.

BRASSY. Applied to coals which are spoilt by the presence of iron pyrites.

BULLS or BALLS. Concretionary nodules containing ironstone, found in some coal-seams.

BURN. The common name for a stream.

CAM. Hardened shale (baked by whin).

CARRS (OUTCARRS). Reefs of rock on the foreshore—if some distance from the land sometimes called *outcarrs*.

CAST. A large drain or cut.

CAST OUT. To crop out to the surface.

CHALK-STONE. A soft, generally whitish, clayey parting in a coal-seam.

CHESTERS. Camps.

COVER. Drift or shale above workable stone in a quarry.

CROW COAL. A poor coal, generally thin. Sometimes used as a name for a particular seam.

CUTHBERT'S BEADS. Joints of encrinite stems.
 — on a rock by Lindisfarn,
 Saint Cuthbert sits, and toils to frame
 The sea-born beads that bear his name.

Marmion : Canto II.

DANT or DENT. Hard shaly clay. Dent is the form commonly used.
 Dent (Norham) will mark on a slate.

DANTY or DENTY. Clayey or shaly.

DARG. A day's work.

DAY. The *day* is the surface of the ground. The coal comes "to the day," i.e., it crops out.

DAYFALL. Fall of earth, &c. at the surface into the underground workings. Often a line of dayfalls marks the outcrop of a seam in shallow workings.

DAYLEVEL or DAYDRIFT. A level that comes to the surface.

DEAN or DENE. A common name for a small and narrow stream-valley.

DIP or DOWNCAST DYKE. Fault regarded from the upthrow side.

DISH. A geological basin or synclinal with a dip everywhere towards the centre.

DIVOT. Peat or turf: e.g., the *divot* hills.

DODD. One of the names for a hill.

DOWNCAST. Applied to a fault. See DIP above.

DUN. Of a brown colour. Applied to more than one limestone.

DUNNISH. Brownish.

DUNSTONE. There are two limestones that go by this name.
DYKE. A common name for a fault.

FAAD or FAKE. A bog (?)
FALLEN. A kind of fireclay. (Helburn).

"FLINGS HERSEL' OUT." Crops out.

FOUL COAL. Impure coal.

FREESTONE. Sandstone generally, as well as that kind which can be cut in any direction.

FREESTONE BANDS. Sandstone in thin beds.

FRONT OF --. Farther to the rise.

GIRDLES. Thin sandstone bands occurring in shale.

GLITTERS or GLIDERS. Lines or trains of fallen blocks down a steep hill-side.

GROUND COAL. The lowest part of the seam ; the same as Bottom Coal.

HANG. Dip of beds.

HARD PAN. Same as MOORBAND—which see.

HAUD. Breadth of coal-workings from one pit or line of pits.

HAUGH. Alluvial land along a river side.

HEUGH. A craggy hill.

HIGH, HIGHER. Thick, thicker ; generally applied to coals and limestones.

HONCS. Kind of oil shale. (Holburn).

KAIM or KAME. A gravelly or sandy hill of great length in proportion to its breadth.

KEEL. Ruddle ; stuff that will mark sheep.

KERVING or KIRVING. Under cutting ; e.g., "soft thill for kerving."

KNOWE. A small green hill.

LAW. A hill.

LETCH. A wet ditch or narrow swamp.

LINKS. The blown sands of the sea-shore.

LINN. A waterfall.

LOW, LOWER. Thin, thinner ; applied to coal-seams.

LOW. A burn.

MACKER, MACKET or MAWKRE. A shaly coal, or coaly shale that will burn but leaves a residue or "ghaist."

METAL or METTLE. The most common name for hard shales. Also road-stone.

METAL STONE. Shaly sandstone.

METAL TILLS. Harder shales.

METTLEY. Shaly.

MOORBAND or HARD PAN. Subsoil (often gravelly) cemented into a solid mass by oxide of iron, &c.

MOSS. A peat-bog.

MUCKLE. Big.

NICK. A pass between the hills.

NIP or NITHER. A sudden thinning of a coal-seam owing to the roof and seat coming together.

ONPUT. Impure limestone at the top of a quarry, not worked.

OPENCAST. A level worked in the open like a large ditch.

OUTBURST. Outcrop.

PAN. See MOORBAND.

PANEL. Stratum.

PARROT. Cannel ; sometimes it is oil shale.

PIPPED or SCARED. Streaked with thin Coal ; showing traces.

POST. Sandstone generally ; sometimes a bed of limestone.

RAMBLE. Broken rock at the surface of the ground.

RAMBLY. Broken up.

RANK. A row or line of coal-pits down to the same water-level.

RED or REDEL. Same as KEEL, which see.

RED or BEARING. The drift, &c. above the workable stone in a quarry.

RIGG. A ridge.

RISE DIKE or UPCAST. A fault regarded from the downthrow side.

SAGGER or SEGGAR. Soft grey or whitish clay, often associated with coal-seams.

SCALP. Thin band (?)

SCAME or SKAME. A stain or spot.
SCAMY. Stained or spotted.
SCARE. A shred or piece ; a thin fragment.
SEAT. The rock on which the coal lies.
SEAVY. Smooth (?)
SHE. Applied to a coal seam, *e.g.*, "She crops out."
SHELLY. Shaly, thin-bedded.
SIKE. A small stream.
SILL. A bed of rock.
SINKING. A shaft.
SITHERING. Bubbling or boiling.
SKERRS. Rocks on foreshore.
SLAKES. Muddy foreshores.
SLIP DYKE. A downthrow fault.
SMITHY COAL. Coal that breaks into small pieces.
SNOOK. A headland.
STAPLE. Sinking or rise inside a pit.
STEEL. A reef or ridge, on shore or in the sea.
STREAK. Strike of beds. Water-level course.
SULPHUR BALLS. Concretionary ironstone with specks of iron pyrites.
SUMP. A sinking inside a mine below the level of the workings. The well at the bottom of the engine shaft.
SWAD. A coaly shale. Sometimes miners call it a *denty* coal.
SWELLIES. Depressions of coal seams, both roof and floor, into a trough. The coal is generally thicker in these.
TENDER. Soft and easily broken ; applied to a coal.
TILL, TILLS or THILLS. Shales.
TILLY FREESTONE. Shaly sandstone.
THILL. Coal seat.
THILL or METAL STONE, which see.
TOP COAL. The uppermost part of a coal-seam.
TRouble. Any kind of defect ; *e.g.*, "when the trouble gets into her she's of no use"—spoken of a whin dyke, also a fault.
UNWATER. To drain.
UPCAST. Upthrow.
WASH. Drift generally.
WATERLEVEL. Used for strike of beds below the surface.
WEEMS. Caves.
WINNING. Getting coal or sinking a shaft to work it. "New winning" is a common name for a new shaft.
WHIN. Any very hard rock, as well as more commonly basalt. Whin sandstone occurs in the Holburn Colliery section.
WHIN SILL. Intrusive basalt in the form of a sheet.

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